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Design and Evaluation of a Terrestrial Model Ecosystem for Evaluation of Substitute Pesticide Chemicals

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16. ABSTRACT

This grant was established to design a terrestrial model ecosystem that was simple, inexpensive, and suitable for examining the total environmental fate of radiolabeled pesticides in a soil crop model e.g. soil-corn or soil-soybean. This was accomplished with the practical development of a system in which corn or soybeans are grown on 3 kg of typical Illinois soil types contained in a 19 l wide-mouth glass carboy fitted with airtight lid and impingers to sample pesticide content in aspirated air, and a bottom petcock to sample leachate water. The units are housed in an environmental growth chamber under 12 hours simulated daylight, at 26°C. Emphasis was placed on tracing the fate of the pesticide chemical and its degradation products in soil, air, water, phytoplankton and in the major food chain organisms of the model ecosystems, e.g. Zea mays, Glycine max, Lumbricus terrestris, Limax maximus, Armadillidium vulgare, Estigmene acrea, and Microtus ochregaster in the soil-plant phase; and Daphnia magna, Culex pipiens quinquefasciatus, Physa spp., and Gambusia affinis in the leachate water. The ^{14}C-labeled pesticides examined included DDT, methoxychlor, aldrin, dieldrin, fonofos, phorate, parathion, methyl parathion, simazine, trifluralin, 2,4,5-T isooctyl ester, hexachlorobenzene, pentachlorophenol, pentachloronitrobenzene, and captan. Detailed summaries of their fate and degradation, based on more than 20,000 analyses, are presented.

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DESIGN AND EVALUATION OF A TERRESTRIAL MODEL ECOSYSTEM

FOR

EVALUATION OF SUBSTITUTE PESTICIDE CHEMICALS

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FOREWORD

Effective regulatory and enforcement actions by the Environmental Protection Agency would be virtually impossible without sound scientific data on pollutants and their impact on environmental stability and human health. Responsibility for building this data base has been assigned to EPA's Office of Research and Development and its 15 major field installations, one of which is the Corvallis Environmental Research Laboratory (CERL).

The primary mission of the Corvallis Laboratory is research on the effects of environmental pollutants on terrestrial, freshwater, and marine ecosystems; the behavior, effects and control of pollutants in lake systems; and the development of predictive models on the movement of pollutants in the biosphere.

This report provides a description of a new method for the evaluation of chemicals in the environment. In addition the results of tests on selected pesticide chemicals are reported.

James C. McCarty
Acting Director, CERL

ABSTRACT

This grant was established to design a terrestrial model ecosystem that was simple, inexpensive, and suitable for examining the total environmental fate of radiolabeled pesticides in a soil crop model, e.g. soil-corn or soil-soybean. This was accomplished with the practical development of a system in which corn or soybeans are grown on 3 kg of typical Illinois soil types contained in a 19 l. wide-mouth glass carboy fitted with air-tight lid and impingers to sample pesticide content in aspirated air, and a bottom petcock to sample leachate water. The units are housed in an environmental plant growth chamber under 12 hours simulated daylight, at 26°C.

Emphasis was placed on tracing the fate of the pesticide chemical and its degradation products in soil, air, water, phytoplankton and in the major food chain organisms of the model ecosystems, e.g. *Zea mays*, *Glycine max*, *Lumbricus terrestris*, *Limax maximus*, *Armadillidium vulgare*, *Estigmene acrea*, and *Microtus ochregaster* in the soil-plant phase; and *Daphnia magna*, *Culex pipiens quinquefasciatus*, *Physa* spp., and *Gambusia affinis* in the lechate water.

The ^{14}C-labeled pesticides examined included DDT, methoxychlor, aldrin, dieldrin, fonofos, phorate, parathion, methyl parathion, simazine, trifluralin, 2,4,5-T isooctyl ester, hexachlorobenzene, pentachlorophenol, pentachloronitrobenzene, and captan. Detailed summaries of their fate and degradation, based on more than 20,000 analyses, are presented.

This report was submitted in fulfillment of EPA Grant No. R-80-3249 by the University of Illinois under the sponsorship of the U.S. Environmental Protection Agency. This report covers a period from July 1974 to September 1977 and work was completed as of July 1978.

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In this Contract, Robert L. Metcalf was Principal Investigator and Larry K. Cole was Project Coordinator.

INTRODUCTION

Pesticides are used as purposeful environmental contaminants and the user generally appears confident that the benefit/risk ratio is tilted decidedly toward the benefit side. This is, however, not always the case and the unbridled use of pesticides has come more and more into question as one of the most important deterrents to environmental quality. Certain widely used, persistent organochlorine pesticides have been judged as presenting an unacceptable environmental risk and the use of DDT, aldrin, dieldrin, heptachlor, and chlordane has been or is in the process of being banned by the Environmental Protection Agency. A number of other pesticides are under Rubuttable Presumption Against Reregistration (RPAR). Nevertheless, modern U.S. agriculture is almost inextricably linked to the widespread use of insecticides, herbicides, fungicides and nematocides. During the past 30 years, the U.S. usage of these materials has increased from about 100 million to 1,300 million lb. annually and the number of active ingredients from less than 100 to more than 1000.

The exponentially increasing use of pesticides in U.S. agriculture at a growth rate of 6.5% per year (Pesticide Review 1976) and the rapid introduction of new pesticide products presents a continuing demand for evaluation and surveillance of the effects of pesticides upon environmental quality. The ecological effects of many widely used pesticides are not well understood and a recent survey (Von Rumker and Horay 1973) concluded that for 20 of the 35 most widely used pesticides, there was inadequate information about the nature of the environmental degradation products and their effects on environmental quality. This problem becomes increasingly acute as more suitable substitute pesticides are sought to replace the broad spectrum persistent pesticides that society has judged and found unacceptable.

Our laboratory at the University of Illinois has pioneered in the development of model ecosystem technology to evaluate the environmental effects of radiolabeled pesticides under controlled laboratory conditions. Our terrestrial-aquatic model ecosystem has been used to evaluate a variety of problems arising from pesticide development and use (Metcalf 1977) and 50 pesticides have been screened under uniform conditions to develop a cohesive picture of their environmental properties (Metcalf and Sanborn 1975).

The present research project is an effort to develop a comparable laboratory model ecosystem to evaluate the suitability of pesticides as used to protect row crops in the agroecosystem. We believe that manufacturers, regulatory agencies, and research workers all require reliable and economical methods for predictively screening the environmental effects and fate of candidate pesticidal compounds in the terrestrial agricultural environment.

Some of the critical objectives of this study have been to (1) develop a dynamic living interacting physical indoor system in which to study radiolabeled pesticides thoroughly and safely, (2) compare the environmental behaviors of various pesticides under homologous and reproducible agricultural conditions, (3) obtain reliable quantitative and qualitative data economically and quickly, (4) ascertain the comprehensive environmental fates of pesticides coherently in soil, air, water, crops, invertebrate and vertebrate terrestrial animals, and aquatic organisms, (5) work year round regardless of the outdoor weather, (6) produce indoor results that are indicative of the outdoor environmental behaviors of the compounds, (7) determine the effects of different types of soils, (8) test both preemergent and postemergent pesticide applications, (9) assess the short-term environmentally toxic effects of normal doses of pesticides, and (10) predict the chronic behaviors and effects of the compounds investigated.

Emphasis is placed on the evaluation of the pesticide in regard to toxicity, degradation, accumulation, and distribution. It is important to note that these are interdependent parameters and not independent processes. The above parameters are examined in the following components of the model ecosystem: representative Air, Soil, Plants, Insecta, Crustacea, Annelida, Mollusca, Mammalia, Surface Waters, Sediments, Leachates, Phytoplankton, Zooplankton, Aquatic Mollusca, Aquatic Insects, and Osteichthyes. The entire model ecosystem is maintained for less than 30 days. By definition, one cannot directly determine the chronic adverse biological effects of a given compound in a short period of time. However, such a compound's potential chronic hazard can be estimated by comparing its environmental fate (degradation, distribution, etc.), under homologous conditions, with the fates of those compounds which have been studied intensely for long periods of time. Compounds which have similar fates and similar acute toxicities will likely have similar chronic toxicities. To further complete the estimate of the chronic toxicity of the given compound, the acute toxicities of all of its degradation products should be determined if they have a tendency to accumulate in vital components of the environment; a chemical change in the parent compound does not necessarily bring about detoxification. One of the strongest advantages of using a radiolabeled parent compound is that it enables one to quantitatively keep track of all degradation products even though their chemical identities and toxicities may not yet be known.

DATA PRESENTATION AND USEFUL REFERENCE POINTS

Frequently an outdoor "pesticide residue" as determined by gas chromatography (GC) is the result of an analysis of either the extractable parent compound only, or a combination of the extractable parent compound plus selected "major extractable metabolites". The results are then adjusted (concentrations increased) based upon an estimate of the extraction efficiency of the parent compound. The quantitative values in the present report were determined by liquid scintillation analyses, not GC, and the entire residue was positively quantified: an individual "total ^{14}C-pesticidal residue" is the combination of "extractable parent compound" (EP), "all extractable ^{14}C-metabolites" (EM) derived from the parent compound, and the "unextractable ^{14}C-products"(UN) remaining in the processed sample, The entire extractable fraction (parent plus metabolites) was quantified before it underwent any clean-up procedure and before an aliquot (or all) of it was chromatographically separated into its various components that were identified and quantified. The chemical nature of the unextractable (or bound) radioactive material is unknown since it was quantified by either thermal destructive oxidation or by chemical disintegration; however, it is often assumed to represent conjugated or chelated derivatives of the parent compound or metabolites. All absolute quantities of parent compounds are presented in µg, and the absolute quantities of all ^{14}C-derivatives are presented as µg of parent compound equivalents. All ppm concentrations are µg chemical/g fresh (wet) weight of material. Concentration in air is given as mg/m^3, which is the same as a ppm (w/w) assuming one liter of air weighs one gram.

The initial pesticide concentration in the most massive component of the model ecosystem, the terrestrial substrate, is a useful reference point when comparing the degree of pesticide accumulation in the various components of the model ecosystem. A given system contained either vermiculite or soil (described below) which differ in density, and the simulated acre depth of all systems was ca. 3 inches (7.5 cm). (Outdoor studies frequently assume an acre depth of 6 inches weighing two million pounds.) All individual systems were treated with 5000 µg of a single pesticide (neat), which simulated a realistic application rate of one lb. active ingredient (AI) per acre (or 1.12 kg/ha). For preemergent applications to systems containing soil, this rate resulted in an initial pesticide concentration in substrate of 1.25 ppm; the initial pesticide concentration in vermiculite was 2.08 ppm.

MATERIALS AND METHODS

The basic ecosystem unit (Figure 1) was a 19-liter wide-mouth glass carboy 46 cm high with a base diameter of 26 cm. The metal lid, which was on the carboy only when air was being trapped, was equipped with inlet and outlet stainless steel tubing to periodically monitor pesticide vapors in air. Each carboy contained either 400 g of vermiculite (Terra-Lite, W. R. Grace and Co., Cambridge, Mass.) or 3000 g of Drummer silty clay loam soil (particle diameter 2.4 - 4.8 mm). The general soil characteristics were: 9.5% sand, 60.2% silt, 30.3% clay, and 7.1% organic matter. Fifty corn seeds (*Zea mays*, Pioneer Hi-Bred 3334A, St. Joseph, Ill.) were uniformly planted in each carboy at a depth of one cm. For preemergent application of a pesticide (Figure 2), a total of 5 mg of radiolabeled compound in one ml of acetone was injected (20 µl per injection) at a depth of one cm beside each of the seeds. For postemergent application, the same amount of compound in one ml of acetone was applied to each plant (20 µl per plant) ten days after planting the system. This rate simulated a one pound active ingredient per acre application, which is the commonly used treatment rate in the field. Vermiculite ecosystems were sprinkled with two liters, and soil ecosystems with one liter, of Freeman's standard reference water (Freeman, 1953). Each system was weighed after planting and watering, and again 7 and 14 days later at which times enough distilled water was added with a sprinkler to restore the initial wet weight, thus simulating two rains and compensating for the evaporation of water.

The following invertebrate animals were added to the system on Day 10: *Estigmene acrea* (Drury), the saltmarsh caterpillar; *Limax maximus* L., a garden slug; *Lumbricus terrestris* L., an earthworm; and *Armadillidium vulgare* (Latreille), a pillbug. Samples of each invertebrate species were analyzed for pesticide residue on Day 15, at which time the prairie vole, *Microtus ochrogaster* (Wagner), was added to the system. It was supplied with a cup of fresh water daily, and removed for analysis on Day 20. Any readily visible plant debris and invertebrate animals remaining in the terrestrial phase were removed on Day 20 and disgarded; the substrate was then mixed well and sampled for analysis. After substrate sampling on Day 20, the ecosystem was flooded with 7 liters of standard reference water, and snails (*Physa* sp.), mosquito larvae (*Culex pipiens quinquefasciatus*) and water fleas (*Daphnia magna*) were added. Three fish (*Gambusia affinis*) were added on Day 24, and all aquatic organisms were removed for analysis on Day 27. The water was decanted at this time. The wet sediment was left in the container for 1 or 5 days and then mixed well and sampled for analysis. The ecosystem units were housed in a 244 x 132 x 198-cm walk-in environmental plant growth chamber (PGW 36, Controlled Environments, Pembina, N. Dak.) which was operated at the following parameters: light/dark phase, 12:12 hours; continuous air circulation; day air temperature, 26°C; night air temperature, 19°C; day substrate temperature, 24-26°C; night substrate temperature, 20-21°C; relative humidity, 50%; light intensity at substrate surface, 1000 foot-candles.

Air was routinely monitored for a three-hour daylight period at a flow rate of 10 ml/sec on the days designated in Figure 2. The inlet tube of the ecosystem carboy was connected by means of silicone rubber tubing, fitted with a needle valve, to a Silent Giant^R aquarium pump (Aquarium Pump Supply, Inc., Prescott, Ariz.) providing a slight positive pressure within the carboy, which "pushed" the air from the carboy to the gas traps which were connected in series and terminated with a flow meter. The gas traps consisted of two 125-ml gas washing bottles connected in series with glass tubing to a flow meter, shown in Figure 1. The first trap (closest to the ecosystem carboy) contained 75 ml of acetonitrile, and the second trap contained 75 ml of a solution of ethanolamine and 2-methoxyethanol (1:2 by volume). The volatile radioactive products trapped in these solutions were quantified by direct scintillation counting using the scintillation fluid, Aquasol^R (New England Nuclear), and a Packard Tri-Carb Model 3320 scintillation counter.

The detailed work-up for the determination of the radioactive content of the biological samples is presented in the Appendix (p.277). It will only be summarized here. The biological samples were homogenized with cold acetone and the total radioactivity determined in the supernatant. The acetone-unextractable radioactivity in the pellet after centrifugation was determined by dissolving the pellet in Protosol^R for 48h at 50°. Soil was homogenized in acetone, filtered, rehomogenized in methanol and the radioactivity in the acetone and methanol filtrates determined and summed. The unextractable radioactivity was determined by combustion to $^{14}CO_2$. Water samples were counted directly in Aquasol^R. The separation, identification, and quantification of degradative products and metabolites from living organisms and soil was carried out by thin-layer chromatography on silica gel followed by autoradiography and determination of the total amount of the radioactive TLC spots by scraping the appropriate areas of silica gel into scintillation vials for counting.

The following ^{14}C labeled pesticides were ring-labeled, except for captan ($^{14}C-Cl_3$). phorate ($^{14}CH_2$), and fonofos ($O^{14}C_2H_5$). Their specific activity and source of supply (mCi per m mol) is shown in the Appendix (p.). The final adjusted specific activity is shown in parenthesis. Fifty microcuries were added to each individual model ecosystem.

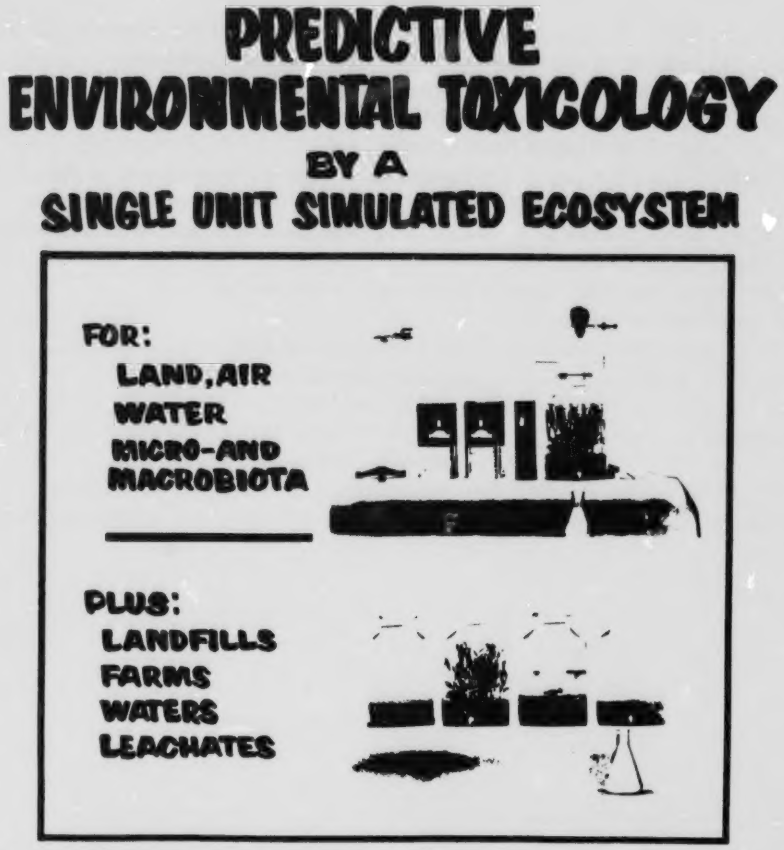
PREDICTIVE
ENVIRONMENTAL TOXICOLOGY
BY A
SINGLE UNIT SIMULATED ECOSYSTEM
FOR:
LAND, AIR
WATER
MICRO-AND
MACROBIOTA
PLUS:
LANDFILLS
FARMS
WATERS
LEACHATES

Figure 1. Physical model ecosystem : (top) arrangement for periodically monitoring volatile components and for evaluating leaching and run-off; (bottom) terrestrial and aquatic sequential phases.

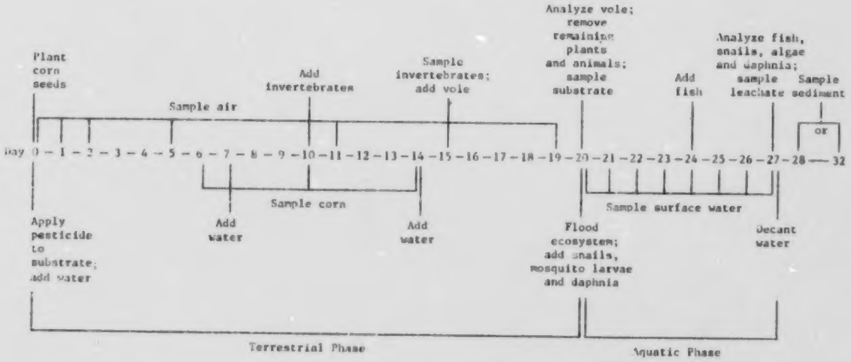
Analyze vole; remove remaining plants and animals; sample substrate
Analyze fish, snails, algae and daphnia; sample leachate
Plant corn seeds
Add invertebrates
Sample invertebrates; add vole
Add fish
Sample sediment
Sample air
or
Day 0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 11 – 12 – 13 – 14 – 15 – 16 – 17 – 18 – 19 – 20 – 21 – 22 – 23 – 24 – 25 – 26 – 27 – 28 — 32
Sample corn
Sample surface water
Apply pesticide to substrate; add water
Add water
Add water
Flood ecosystem; add snails, mosquito larvae and daphnia
Decant water
Terrestrial Phase
Aquatic Phase

Figure 2. Time sequence for the model ecosystem when using a preemergent substrate pesticide application; postemergent foliar applications are made at day 10, the air-monitoring is shifted to days 10, 11, 12, 15 and 19, and the corn is sampled on days 12 and 14.

Methoxychlor (1.61): 1,1,1-trichloro-2,2-*bis* (*p*-methoxyphenyl)ethane
DDT (3.54): 1,1,1-trichloro-2,2-*bis*(*p*-chlorophenyl)ethane
Fonofos (2.70): *O*-ethyl *S*-phenyl ethylphosphonodithioate
Aldrin (3.10): 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-*endo*, *exo*-5,8-dimethanonaphthalene
Dieldrin (3.68): 1,2,3,4,10,10-hexachloro-*exo*-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-*endo*,*exo*-5,8-dimethanonaphthalene
Phorate (8.45): *O*,*O*-diethyl-*S*-(ethylthio)methyl phosphorodithioate
HCB (5.33): hexachlorobenzene
PCNB or quintozene (4.32): pentachloronitrobenzene
PCP (2.55): pentachlorophenol
Captan (2.99): *N*-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide
Simazine (4.00): 2-chloro-4,6-*bis*(ethylamino)-s-triazine
Trifluralin (7.05): α,α,α-trifluoro-2,6-dinitro-*N*,*N*-dipropyl-*p*-toluidine
2,4,5-T (isooctyl ester) (6.95): 2,4,5-trichlorophenoxyacetic acid, isooctyl esters (mixed)
Parathion (4.16): *O*,*O*-diethyl *O*-*p*-nitrophenyl phosphorothioate
Methyl parathion (5.60): *O*,*O*-dimethyl *O*-*p*-nitrophenyl phosphorothioate

RESULTS AND DISCUSSION

This investigation was made to develop a simple, practical terrestrial model ecosystem for study of the total fate of pesticides in the typical corn-soil and soybean-soil agroecosystems that comprise about 100 million A of farmland in the "corn belt" of the Mid West. Much of this farmland has been treated with highly persistent organochlorine pesticides during the past 25 years and the use of insecticides, herbicides, and fungicides as pre-and post-emergent applications has increased from about 39.5 million lb. in 1964 to 62.3 million lb. in 1966, and to 96.5 million lb. in 1971 (NAS 1975). There is little overall or comparative information about the fate of the various active ingredients applied, in the soil, air, water or biota and the rate of introduction of new pesticides is far beyond the capacity of any environmental monitoring program for surveillance.

The laboratory terrestrial model ecosystem methodology, comprehensively described, has been validated by studies with 15 radiolabeled pesticides. The unequalled analytical capability of the ^{14}C labeled compounds has produced more than 20,000 individual measurements about the qualitative and quantitative fate of these pesticides in the organisms of the model ecosystem and in the air, water, and soil (detailed in the 170 Tables and 100 Figures of this report). This wealth of information has scarcely been tapped as a resource about the ecology of pesticides, and remains as a major resource for evaluation of the comparative fate of pesticides in a variety of living organisms, e.g. corn, soybean, earthworm, slugs, caterpillar, and vole. Equally interesting comparisons can be made of the distribution and fate of the 15 radiolabeled pesticides in the soil, air, and water environment. This larger body of information serves to demonstrate the value of the laboratory model ecosystem.

In order to facilitate comparisons of the basic data, the three "grand summaries" Tables 1, 2, and 3, will be most useful. These show the total distribution of ^{14}C pesticide residues for the 15 compounds studied. These are based on the highly detailed Tables presented under each material. Many additional calculations can be made easily from these Summary Tables - but with caution. For example, in Table 3, if you average the values in the row across from the heading "vole", you find that the average percent of extractable parent compound detected in the total ^{14}C-pesticidal residues examined in the vole was 19%. However, for dieldrin, 89% of the residues in the vole was parent compound. In contrast, for fonofos and 2,4,5-T ester there was no parent compound found in the vole. The other pesticides fell in the range between these values. It is clear, therefore, that this set of values gives a precise clue to bioaccumulation and food chain transfer. It is, therefore, a good idea to glance across the entire row of values in Tables 1-3 to note the extremes and trends (medians) for the pesticide residues in the various substrates. In calculating an average value across the row, the mode of pesticide application, the time of application, and the type of terrestrial substrate are essentially

Table 1.—Grand summary no. 1: total ^{14}C-pesticidal residues, ppm, in terrestrial-modular model ecosystems

Ecosystem component and postplanting age at analysis (days)	Vermiculite substrate					Soil (silty clay loam) substrate[a]													
	Postemergent application		Preemergent application															Postemergent application	
	Meth-oxy-chlor	DDT	Fono-fos	Diel-drin	Aldrin	Aldrin	Diel-drin[b]	Pho-rate (loam)	Pho-rate (sand)	HCB (soy-beans)	HCB (corn)	PCNB	PCP	Cap-tan	Sima-zine	Tri-fluralin (s'beans)	2,4,5-T (es-ter)[c]	Para-thion	Me. para-thion
Substrate (20)[d]	1.44	1.73	0.212	1.41	0.882	1.26	0.828	0.852	0.518	1.06	0.949	0.858	0.634	0.165	1.44	1.13	1.07	0.577	0.398
Air (5 or 15)[e]	0.002	0.0004	0.004	0.006	0.029	0.003	0.002	0.027	0.041	0.008	0.014	0.017	0.078	0.094	0.0003	0.004	0.005	0.017	0.276
Corn/soybeans (14)[f]	13.6	12.6	1.10	5.66	8.05	0.721	···	1.59	6.48	1.15	2.64	9.25	6.30	0.396	1.39	1.56	1.09	42.9	24.5
Earthworm (15)	2.06	2.24	···	3.62	4.13	1.26	0.698	0.457	1.91	4.46	0.584	1.39	0.551	0.181	4.90	4.29	1.81	1.29	3.07
Slug (15)	2.09	5.81	0.404	0.771	2.58	0.391	0.184	0.376	2.03	0.195	0.228	0.441	0.212	0.069	···	0.472	···	2.31	0.955
Pillbug (15)	4.22	5.53	···	8.87	3.22	0.870	0.475	0.864	1.40	1.53	4.09	1.77	0.618	0.470	2.01	0.587	2.69	9.71	6.66
Caterpillar (15)	6.29	85.9	1.04	1.34	3.38	0.502	0.275	0.459	2.01	0.656	0.347	2.44	1.45	0.299	0.444	0.326	0.163	13.5	2.36
Vole (20)	0.469	11.9	0.270	3.67	1.31	0.471	0.947	0.128	0.335	0.695	2.88	0.677	0.530	0.119	0.077	0.224	0.036	0.304	0.532
Water (27)				0.022			0.004	0.047	0.083	0.0012	0.0017	0.009	0.008	0.003	0.059	0.009	0.067	0.007	0.007
Sediment (28 or 32)[d][g]				0.894			0.762	0.546	0.281	0.829	0.818	···	···	···	0.888	0.882	0.795	0.630	0.455
Snail (27)				70.3			8.70	0.226	0.821	0.801	0.546	1.60	2.52	0.825	0.133	0.571	0.193	1.35	1.19
Fish (27)				62.6			7.61	0.527	0.772	2.38	1.13	1.72	1.76	0.378	0.207	0.059	0.149	0.223	0.236
Daphnia (27)				8.81												0.146	0.231		

[a] One Phorate ecosystem contained Bloomfield loamy sand soil; all other ecosystems contained Drummer silty clay loam soil.
[b] No corn plants were present in this ecosystem.
[c] 2,4,5-T (isooctyl ester).
[d] For Methoxychlor, DDT, Fonofos, Dieldrin and Aldrin, value represents extractable ^{14}C only; for Aldrin, 100% of ^{14}C-pesticide was extractable.
[e] Air was analyzed on Day 5 for preemergent application ecosystems and Day 15 for postemergent application ecosystems.
[f] Soybeans were grown in one HCB and the Trifluralin ecosystems; corn was grown in all other ecosystems.
[g] Sediment from HCB, Phorate, Simazine, 2,4,5-T and Trifluralin ecosystems was analyzed on Day 28; all others on Day 32.

Table 2.—Grand summary no. 2: extractable parent ^{14}C-pesticidal compounds, ppm, in terrestrial-modular model ecosystems

Ecosystem component and postplanting age at analysis (days)	Vermiculite substrate					Soil (silty clay loam) substrate[a]													
	Postemergent application					Preemergent application												Postemergent application	
	Methoxychlor	DDT	Fonofos	Dieldrin	Aldrin	Aldrin	Dieldrin[b]	Phorate (loam)	Phorate (sand)	HCB (soybeans)	HCB (corn)	PCNB	PCP	Captan	Simazine	Trifluralin (s'beans)	2,4,5-T (ester)[c]	Parathion	Me. parathion
Substrate (20)[d]	0.886	1.12	0.016	1.21	0.125	0.840	0.722	0.010	0.007	1.02	0.904	0.369	0.119	0.002	1.01	0.888	0.040	0.104	0.015
Air (5 or 15)[e]	0.002	0.0004	0.004	0.006	0.029	0.003	0.002	0.027	0.041	0.008	0.014	0.017	0.078	0.094	0.0003	0.004	0.005	0.017	0.276
Corn/soybeans (14)[f]	11.4	9.57	0.175	3.80	1.55	0.115	...	0.038	0.028	0.794	1.36	1.08	1.01	0.004	0.448	0.598	0.019	10.9	0.596
Earthworm (15)	0.316	1.18	...	0.255	0.223	0.070	0.011	0.003	0.014	4.10	0.530	0.146	0.046	0.0	3.24	2.35	0.007	0.556	0.092
Slug (15)	0.700	3.87	0.012	0.554	0.182	0.012	0.137	0.0	0.0	0.154	0.156	0.042	0.035	0.028	...	0.257	...	1.47	0.053
Pillbug (15)	1.10	3.48	...	7.59	0.247	0.095	0.138	0.0	0.0	1.49	3.85	0.511	0.022	0.053	0.213	0.182	0.0	1.97	0.150
Caterpillar (15)	2.83	2.98	0.0	1.26	0.180	0.032	0.257	0.049	0.172	0.564	0.286	0.973	0.541	0.019	0.292	0.209	0.035	3.19	0.224
Vole (20)	0.041	1.37	0.0	3.29	0.150	0.008	0.843	0.002	0.004	0.484	2.27	0.051	0.037	0.002	0.016	0.061	0.0	0.013	0.005
Water (27)				0.009			0.002	<0.0001	0.0001	0.0005	0.0008	0.0002	0.001	<0.0001	0.047	0.0	0.0	0.0003	0.0001
Sediment (28 or 32)[d/g]				0.745			0.678	0.022	0.011	0.749	0.701	...	...	...	0.526	0.106	0.026	0.029	0.0013
Snail (27)				62.9			8.02	0.004	0.019	0.458	0.319	0.350	0.046	0.048	0.103	0.170	0.009	0.030	0.0
Fish (27)				58.1			7.25	0.063	0.075	1.36	0.420	0.171	0.779	0.021	0.096	0.007	0.007	0.008	0.038
Daphnia (27)				8.05												0.012	0.014		

a/ One Phorate ecosystem contained Bloomfield loamy sand soil; all other ecosystems contained Drummer silty clay loam soil.
b/ No corn plants were present in this ecosystem.
c/ 2,4,5-T (isooctyl ester).
d/ For Methoxychlor, DDT, Fonofos, Dieldrin and Aldrin, value represents extractable ^{14}C only; for Aldrin, 100% of ^{14}C-pesticide was extractable.
e/ Total ^{14}C-pesticidal residue; air was analyzed on Day 5 for preemergent application ecosystems and Day 15 for postemergent application ecosystems.
f/ Soybeans were grown in one HCB and the Trifluralin ecosystems; corn was grown in all other ecosystems.
g/ Sediment from HCB, Phorate, Simazine, 2,4,5-T and Trifluralin ecosystems was analyzed on Day 28; all others on Day 32.

Table 3.—Grand summary no. 3: resistance to degradation, expressed as the percent of extractable parent compound present in the total ^{14}C-pesticidal residue

Ecosystem component and postplanting age at analysis (days)	Vermiculite substrate					Soil (silty clay loam) substrate[a]													
	Postemergent application		Preemergent application															Postemergent application	
	Meth-oxy-chlor	DDT	Fono-fos	Diel-drin	Aldrin	Aldrin	Diel-drin[b]	Pho-rate (loam)	Pho-rate (sand)	HCB (soy-beans)	HCB (corn)	PCNB	PCP	Cap-tan	Sima-zine	Tri-fluralin (s'beans)	2,4,5-T (es-ter)[c]	Para-thion	Me. para-thion
Substrate (20)[d]	61.53	64.74	7.55	85.82	14.17	66.67	87.20	1.17	1.35	96.23	95.26	43.01	18.77	1.09	70.14	78.58	3.74	18.02	3.77
Air (5 or 15)[e]																			
Corn/soybeans (14)[f]	83.82	75.95	15.91	67.14	19.25	15.95	...	2.38	0.43	69.04	51.52	11.68	16.03	1.01	32.23	38.33	1.74	25.41	2.43
Earthworm (15)	15.34	52.68	...	7.04	5.40	5.56	1.58	0.66	0.73	91.93	90.75	10.50	8.35	0.0	66.12	54.78	0.39	43.10	3.00
Slug (15)	33.49	66.61	2.97	71.85	7.05	3.07	74.46	0.0	0.0	78.97	68.42	9.52	16.51	40.58	...	54.45	...	63.64	5.55
Pillbug (15)	26.07	62.93	...	85.57	7.67	10.92	29.05	0.0	0.0	97.39	94.13	28.87	3.56	11.28	10.60	31.01	0.0	20.29	2.25
Caterpillar (15)	44.99	3.47	0.0	94.03	5.33	6.37	93.45	10.68	8.56	85.98	82.42	39.88	37.31	6.35	65.77	64.11	21.47	23.63	9.49
Vole (20)	8.74	11.51	0.0	89.65	11.45	1.90	89.02	1.56	1.19	69.64	78.82	7.53	6.98	1.68	20.78	27.23	0.0	4.28	0.94
Water (27)				40.85			40.26	0.11	0.12	41.67	47.06	1.71	8.14	0.10	79.66	0.0	0.0	3.91	1.35
Sediment (28 or 32)[d/g]				83.33			88.98	4.03	3.91	90.35	85.70	...	...	...	59.23	12.02	3.27	4.67	0.29
Snail (27)				89.47			92.18	1.77	2.31	57.18	58.42	21.88	1.83	5.82	77.44	29.77	4.66	2.22	0.0
Fish (27)				92.81			95.27	11.95	9.72	57.14	37.17	9.94	44.26	5.56	46.38	11.86	4.70	3.59	16.10
Daphnia (27)				91.37												6.22	6.06		

[a] One Phorate ecosystem contained Bloomfield loamy sand soil; all other ecosystems contained Drummer silty clay loam soil.
[b] No corn plants were present in this ecosystem.
[c] 2,4,5-T (isooctyl ester).
[d] For Methoxychlor, DDT, Fonofos, Dieldrin and Aldrin, value represents extractable ^{14}C only; for Aldrin, 100% of ^{14}C-pesticide was extractable.
[e] Air was analyzed on Day 5 for preemergent application ecosystems and Day 15 for postemergent application ecosystems.
[f] Soybeans were grown in one HCB and the Trifluralin ecosystems; corn was grown in all other ecosystems.
[g] Sediment from HCB, Phorate, Simazine, 2,4,5-T and Trifluralin ecosystems was analyzed on Day 28; all others on Day 32.

ignored, but each of these characteristics substantially effects environmental behavior of the pesticide, as will be discussed later. The major subdivisions (extractable parent compound, extractable metabolites, and unextractable products) of each of the total ^{14}C-pesticides residue values summarized in Table 1, can be located by referring to Figures 3-8 and to the detailed Tables of metabolism of each compound by the major organisms of the model ecosystem.

INTERESTING COMPARISONS

The choice of test variations and pesticides employed allow us to make a number of interesting comparisons about the fate of pesticides in these soil-crop ecosystems. A brief survey of these will demonstrate the great value of the model ecosystem approach and its applicability to problem solving.

SOIL DEGRADATION

The more stable compounds were no more readily degraded in soil than in animals. Aldrin and dieldrin were tested in both vermiculite and soil (Tables 1-3); there was no indication that either of these compounds was more readily degraded in soil containing a rich microflora than in vermiculite. If anything, it appeared that aldrin was more readily degraded in vermiculite than in soil; the ratio of parent compound to total residue was certainly less in vermiculite than in soil. But we really do not know whether these final ratios in substrate were due primarily to degradation that occurred within the substrate itself, or to degradation that occurred principally elsewhere within the ecosystem. Since the substrate is the most massive component of the model ecosystem, it probably is a reflection of the degradation that occurred in the substrate. But we also have to keep in mind that the final ratio of parent compound to total residue in substrate was not solely the result of degradation. Differences in the evaporation rates of parent compound and metabolites could also have easily altered the ratio of parent compound to total residue in the substrate. This was quite possible in the case of aldrin applied to vermiculite, because it was estimated that 53% of the total residue was lost to the atmosphere after 20 days. But in the vermiculite-containing system treated with dieldrin, only 27% of the total residue was lost to the air after the same period of time. The vapor pressure of aldrin (6×10^{-6}mm) is about 33x that of dieldrin (1.8×10^{-7}mm), and the average concentration of aldrin in the air of the model ecosystem was about 6x that of dieldrin (Table 1). Thus, in the system containing vermiculite and treated with aldrin, the small ratio of parent compound to total residue may have resulted because aldrin more readily evaporated from the substrate than did its major metabolite, dieldrin. This is an excellent example of the interdependence of the parameters, degradation and environmental distribution; these measurements are the results of a combination of processes working together simultaneously. But the meaningful point is that the final outcome (parent compound/total residue in substrate) of interacting processes was readily detected and quantified using a model ecosystem.

In another model ecosystem treated with aldrin - the system containing soil - it is very improbable that transportation to the atmosphere was the cause of the change in the ratio of parent compound to total residue in the substrate, because no significant quantity of the residue evaporated. In the aldrin-soil system, the change was truly caused principally by degradation; in the aldrin-vermiculite system, it is very probable that the major portion of the change was caused by evaporation. Thus, although a given table, such as Table 3, may have a single parameter as its heading - such as "degradation" - that does not mean that multiple processes did not affect that measurement or parameter. It is important to note that the relative degrees of degradation (transformation) and distribution (transportation) are not always easy to measure independently in open systems. Fundamental phenomena are often the results of very interdependent processes in any living organism or complex system. Degradation, accumulation, and distribution are fundamentals in the attempts to decipher the environmental fates of toxicants.

EFFECTS OF SOIL TYPES

Phorate was compared as a pre-emergent application in the soil-corn model ecosystem incorporating two typical Illinois soil types: Drummer silty clay loam with 7.1% organic matter and 33.5 cation exchange capacity*, and Bloomfield loamy sand with 2.1% organic matter and 2.3 cation exchange capacity (Figures 64, 67, Tables 1-3). These two soils had markedly different effects on the distribution of the phorate and its oxidation and degradation products. The Drummer soil with its higher sorption capacity retained 49.2% of the total ^{14}C compared to 21.2% retained in the Bloomfield soil. Correspondingly, less phorate and degradation products were released to the leachate water from the Drummer soil (6.6% total ^{14}C) than in the Bloomfield soil (11.6% total ^{14}C). The aspirated air contained 0.041 ppm total ^{14}C from the Bloomfield system vs 0.027 ppm from the Drummer system.

The organisms in the Bloomfield soil system accumulated substantially higher amounts of both total ^{14}C (Table 1) and phorate (Table 2) than Drummer indicating the strong sorbtive capacity of the latter:

	Bloomfield	Drummer
corn	6.48 ppm	1.59 ppm
vole	0.335	0.128
caterpillar	2.01	0.459
earthworm	1.91	0.457
slug	2.03	0.367
pillbug	1.40	0.864

The individual tabulations for the various organisms show the ready oxidation of phorate to sulfoxide (SO) and sulfone (SO_2) and to the corresponding oxons. Detailed comparisons of the fate of these in soils (Tables 109, 117), corn (Tables 110, 118), vole (Tables 113, 121), invertebrates (Tables 112, 120), air Tables 111, 119), and water (Tables 115, 123), and aquatic organisms (Tables 116, 124), show in general the greater availability of phorate from the Bloomfield soil and the consequently more rapid rate of biotransformations into the active oxidation products. These detailed studies illustrate the great amount of detailed information to be secured from model ecosystem studies with radiolabeled pesticides in regard to the qualitative and quantitative ecosystem fate of individual compounds.

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* milliequivalent per 100 g

ENVIRONMENTAL DISTRIBUTION

To ascertain if a toxic substance is likely to be harmful, it is necessary to know where it is likely to be, and to what extent. The distinctly different distributions of the various pesticides and their derivatives among the major environmental compartments of the model ecosystems at the end of the 20-day terrestrial phase are summarized in Figure 9. The detailed explanation as to how a given pesticide's distribution was calculated is shown in Figures 19, 21, 23, 25, 28, 30, 32, 34, 40, 43, 46, 49, 52, 55, 58, 61, 64, 67, 70, 73, and 76.

The major relocation site of all pesticides was either the soil or the atmosphere. For those compounds which were applied directly to Drummer silty clay loam soil containing corn, the maximum amount of any pesticide plus its derivatives detected in the total complement of terrestrial animals was 3.5% of the applied dose (HCB): the minimum amount was 0.22% (captan) and the average amount was 1.5%. Parathion and methyl parathion were carefully and directly applied to corn grown in soil ten days after planting; the respective amounts of their total residues in the total terrestrial animal masses were 3.6% and 3.1% of their applied doses. Thus it appeared that the compounds which were carefully applied (not sprayed) to corn foliage could produce twice as much contamination of the total animal complement after a short period of time than those compounds which were applied to soil. But at this time, we do not know whether the apparent differences in results were primarily due to differences in application techniques, or to differences in pesticides. In comparing parathion (applied to corn) with aldrin (applied to soil) and taking into consideration that they are normally applied as simulated, we would conclude that the long-term, or chronic, potential hazard of parathion to the terrestrial animals in the agricultural environment would be much less than that of aldrin, because 52% of the parathion application was lost to the atmosphere after 10 days, whereas virtually none of the aldrin was lost to the atmosphere after 20 days. As indicated in Figure 9, methyl parathion would be potentially less hazardous than parathion since less of it was transferred to the animals and less remained in the soil. This point is discussed subsequently.

Figure 9 clearly indicates that the chronic potential hazard of the four fungicides would be in order HCB→PCNB→PCP→captan. Their respective transfers to the total terrestrial animal complements were 3.5%, 2%, 1%, and 0.2% of their applied soses. Their respective persistences in soil after 20 days were 67%, 64%, 48%, and 13% of their applied doses (see later discussion).

A change in the type of terrestrial substrate drastically altered the environmental distribution of a given pesticide as is evident by comparing the distributions of aldrin applied to vermiculite with that applied to Drummer silty clay loam soil (organic matter content 72), as shown in Figure 9. The values shown are the averages of duplicate systems containing vermiculite and duplicate systems containing soil. When applied to vermiculite, the resulting major site of pesticide contamination was the atmosphere; when applied to soil, the vast majority of the total aldrin residue remained within the soil. Evidently, aldrin was less tightly bound to vermiculite than to soil. Each species of terrestrial animal in the aldrin-vermiculite system accumulated a greater concentration of total aldrin residue than did its counterpart in the aldrin-soil system, and the same relative relationship was even more pronounced in the corn from the two systems (Table 1).

For the model ecosystems containing vermiculite, the aldrin-treated system is directly comparable to the dieldrin-treated system because they were homologous in all detail except for the type of pesticide (Figure 9). In comparing these two systems, it will be noted that aldrin was more volatile than dieldrin. However, in those systems containing soil, more dieldrin was lost to the atmosphere than aldrin; the probable cause of this was the absence of a growing crop in the dieldrin-soil system. This latter system was accidentally drenched with the proper amount of water (instead of it being slowly sprinkled) which compacted the soil and prevented the seeds from germinating. We do not believe that the complete lack of germination was due to the pesticide, because an aliquot of the same batch of seeds did germinate in the vermiculite-containing system treated with the same compound at the same rate. Soybean (*Glycine max*) and Swiss chard (*Beta vulgaris cicla*) leaves were added to the dieldrin-soil system to serve as food for the animals (corn leaves were not available). If a crop had grown in the dieldrin-soil system, we would have expected the retention of dieldrin in soil to be comparable to, or greater than, that of aldrin in soil. The root system of growing plants in essence contributes a tremendous quantity of organic matter to the soil environment; furthermore, it greatly aids in holding the soil together, thus preventing the formation of deep cracks or fissures which create abundant surface-to-air interfaces which enhance volatilization. It would seem strongly advantageous to have at least a growing crop present in those studies concerned with the fate of agricultural chemicals in agricultural soils. Although the volatilization of dieldrin from vermiculite and from soil-without-a-crop were very similar, the accumulation of dieldrin residues by each animal species was much greater in the system with a growing crop. This implies that the volatilization, as such, was not nearly as significant a factor contributing to pesticide accumulation by animals as was the presence of a growing crop.

PESTICIDE TRANSPORT TO SURFACE WATER AND AQUATIC ORGANISMS

At the termination of the terrestrial phase (Dav 20), many of the systems were each slowly flooded with seven liters of water, the mass of which was 1.75 times greater than that of the moist soil (Figure 10 and Tables 154 and 155). This was certainly a harsh treatment of a land mass with water. Seven days after flooding the systems that contained Drummer soil, the following total percentages of ^{14}C pesticidal residues applied to the terrestrial phase, were detected in water and in aquatic organisms:

	% in water	% in aquatic organisms
PCNB	1.2	0.04
PCP	1.2	0.05
HCB	0.2	0.06
parathion	1.0	0.02
methyl parathion	0.9	0.02
phorate	6.6	0.04
dieldrin	0.5	0.30
captan	0.4	0.01
simazine	8.2	0.02
trifluralin	1.3	0.10
2,4,5-Tester	9.4	0.04

For the system containing vermiculite and treated with dieldrin, 3.1% of the applied dosage was transported to water and 2.3% to the aquatic organisms. Clearly, more total dieldrin residue was transported to the same volume of water from vermiculite than from soil. As noted earlier, the total mass of vermiculite differed from the total mass of soil; thus the concentrations of pesticides in the two substrates are not directly comparable. The 1.41 ppm dieldrin residue in vermiculite at the time of flooding represents an absolute amount of 3,384 μg; the comparable concentration and absolute amount in soil at the time of flooding were, respectively, 0.828 ppm and 3,312 μg. Thus, the absolute amounts of total dieldrin residues in vermiculite and soil were almost equal; yet approximately six times more pesticide residue was transported to the water in the vermiculite system than to the water in the soil system, indicating that the dieldrin residue was about six times more strongly bound to soil than to vermiculite under these conditions.

The amounts of pesticides transported from soil to surface water were quite small compared to the amounts transported from soil to air (Figure 9, Table 155). For the eleven pesticides (indicated above) that were studied in both the terrestrial and aquatic phases, the average ^{14}C-pesticide residue (including metabolites) transferred to water from Drummer silty clay loam soil at the end of the seven-day period of flooding was 2.8% of that which was originally applied to the system, with a maximum of 9.4% (2,4,5-T) and a minimum of 0.24% (HCB). The residues in water for 8 of the 11 compounds were equal to or less than 1.3%. In contrast, and for these same compounds, the average ^{14}C-pesticide residue transferred to air during the 20-day terrestrial phase preceeding the flooding was 40% of the applied dose, with a maximum of 85% (captan) and a minimum of approximately 0% (simazine). For captan, only 0.4% of its applied dose reached water, whereas 87% was earlier lost to air, and the reverse of such a distribution was shown by simazine which lost virtually no residue to air and subsequently had one of the largest residues in water, 8.2%. Thus, it was apparent that the amount of pesticide likely to reach water was dependent upon the pesticide's past history on land, especially its volatilization from land. However, it was noted that pesticides could lose about equal fractions to air (2,4,5-T, 25% and HCB, 29%) and yet have distinctly different proportions end up in water (2,4,5-T, 9.4% and HCB, 0.24%). This indicated that the eventual amount of pesticide to be found in water was also a function of a given pesticide's relative mobility from soil to water (desorption and solubility). The four pesticides that were most abundantly transferred to water (2,4,5-T, simazine, phorate and trifluralin) were the only compounds that killed the fish (Table 154).

As shown in Figure 11, an aquatic organism accumulated a tremendous quantity of pesticide from its surrounding aquatic environment, especially when compared to the general levels accumulated by terrestrial animals from their surrounding environment (Figure 13). For example, the concentration of total dieldrin residue in fish was 1,951 times greater than that found in the surrounding water, whereas the concentration in the vole was approximately the same as that detected in the surrounding soil (Table 1). For total PCP residues (Table 1), the following pesticide concentration ratios were noted: fish/water = 208, snail/water = 297, vole/soil = 0.836, and caterpillar/soil = 2.29. Recall the following exposure periods: 3 days for fish, 5 days for terrestrial animals, and 7 days for aquatic snails. Since the exposure period of the terrestrial animals was bracketed by those of the aquatic animals, there was no indication that the difference in exposure periods was responsible for the large difference in pesticide accumulations by aquatic and terrestrial animals. Clearly, the terrestrial environment is divided into many micro-compartments, it is not a fluid, and the accessibility of the total quantity of terrestrial pesticide to any given individual terrestrial organism is extremely limited.

PESTICIDE EFFICIENCY

The model ecosystem experiments provide some interesting answers to the common speculation regarding the percentage of total pesticide application reaching the target organism. For the post-emergent insecticide applications the total insecticide residue within the salt marsh caterpillars was <1% of the total dosage applied, except for DDT. The amounts recovered were: methyl parathion 0.35% (10% parent compound), parathion 0.6% (25% parent), methoxychlor 0.99% (45% parent), DDT 14.1% (3% parent, 92% DDE). (Figures 19, 21, 52, 55, Tables 6, 11, 80, 88). Parathion killed 88% of the caterpillars, none were killed by the other insecticides.

The four pre-emergent insecticide applications of aldrin, dieldrin, phorate and fonofos would not normally be used to control the salt marsh caterpillar. However, the maximum amount of any of these insecticides detected as a total residue in the caterpillars was 0.09% of the applied dose (phorate).

For the pre-emergent herbicides, the recovery in the plants of the total amount applied was of similar magnitude: simazine 2.8% (32% parent) in corn, trifluralin 0.3% (39% parent) in soybean, 2,4,5-T ester 2.7% in corn (1.7% parent), shown by the detailed data (Figures 70, 73, 76, Tables 126, 134, 142).

For the fungicides the comparison as to target site efficiency is less meaningful. However, the percentages in corn were: captan 0.7% (1% parent), HCB 4% (52% parent) PCNB 18% (11.7% parent), and PCP 16% (16% parent). (Figures 43, 46, 47, 61, Tables 57, 64, 71, 102). In soybean HCB was present to 0.6% of applied dosage (69% parent) (Figure 58, Table 94). Thus these data strongly support the often quoted statement that only about 1% of the total application of pesticide reaches the target organism.

HARD VS SOFT PESTICIDES

A major factor in banning the uses of the "hard" insecticides DDT, aldrin, and dieldrin was to prevent widespread environmental contamination with persistent pesticides and bioaccumulation through food chains. EPA has claimed that suitable biodegradable or "soft" pesticides can be employed as substitutes with consequent improvement in environmental quality. This point was investigated in the terrestrial model ecosystem comparing two pairs of insecticides in pre- and post-emergent applications (Cole et al 1976a, 1976b).

Comparisons were made of aldrin vs fonofos and phorate, substitute insecticides now widely used in corn rootworm control, and DDT vs its biodegradable substitue methoxychlor. The results are shown in Tables 1-3.

ALDRIN VS FONOFOS

At the conclusion of the experiments the soil (vermiculite) contained 0.463 ppm aldirn vs 0.016 ppm fonofos, the corn plants 0.762 ppm aldrin vs 0.175 ppm fonofos and the vole 0.08 ppm aldrin plus 3.48 ppm dieldrin vs 0.0% fonofos plus 0.27 ppm other breakdown products. (Tables 14, 15, 17, 28, 29, 31). These results clearly demonstrate the hazardous environmental conversion of aldrin to the very persistent dieldrin and its bioaccumulation and the biodegradability of fonofos. They agree with the "real world" experience where the use of aldrin has resulted in widespread accumulation of persistent dieldrin residues and where the use of millions of pounds of fonofos has not resulted in any observed bioaccumulation on food chain transfer.

DDT VS METHOXYCHLOR

At the conclusion of these post-emergent experiments, the soil (vermiculite) contained 1.12 ppm DDT vs 0.886 ppm methoxychlor, the corn plant 9.75 ppm DDT vs 11.4 ppm methoxychlor, and the vole 1.37 ppm DDT plus 8.20 ppm DDE, vs 0.041 ppm methoxychlor. (Tables 4, 5, 7, 9, 10, 12). These data clearly show the food chain tranfer and storage of DDT plus DDE and the biodegradability and lack of food chain transfer of methoxychlor. The results are completely in accord with a large amount of "real world" data showing the bioaccumulation and fat storage of DDT as compared with the biodegradability of methoxychlor.

PARATHION AND METHYL PARATHION

This comparison is particularly meaningful because of the very large amounts of these highly toxic pesticides used. Methyl parathion (♀ rat oral LD_{50} 24 mg per kg) is somewhat safer than parathion (♀ rat oral LD_{50} 3.6 mg per kg) and is generally thought to be environmentally less persistent. The comparative model ecosystem data clearly show this to be the case (Tables 1-3). In the Drummer soil of the model ecosystem the methyl parathion concentration at the end of the experiment was 0.015 ppm vs parathion 0.104 ppm. (Tables 2, 77, 85). In the flood waters, the residues were methyl parathion 0.0001 ppm vs parathion 0.0003 ppm. (Tables 2, 83, 91).

The greater volatility of methyl parathion and its derivatives is reflected by the average air samples showing 0.276 ppm for methyl parathion vs 0.017 ppm for parathion (Table 1).

In the corn plants, the parent compound residues were methyl parathion 0.59 ppm vs parathion 10.8 ppm (Tables 78, 86). In the vole at the top of the food chain, the total body parent residues were methyl parathion 0.005 ppm vs parathion 0.013 ppm (Tables 81, 89) although the voles from both systems contained 0.2% of the total ^{14}C applied to the model systems (Tables 2, 3, Figures 52, 55). In the salt marsh caterpillar, the concentration of methyl parathion was 0.22 ppm vs parathion 3.19 ppm (Tables 2, 80, 88).

HCB, PCNB, AND PCP

The comparison of these aromatic organochlorine fungicides (Table 165) is interesting because of the appreciable changes in water solubility and octanol/water partition values between C_6Cl_6 (H_2O solubility 0.006 ppm, partition 13,560) $C_6Cl_5NO_2$ (H_2O solubility 0.001 ppm, partition 16,059) and C_6Cl_5OH (H_2O solubility 14 ppm, partition 6,405). These differences produce substantially different model ecosystem effects as shown in Table 165. In the Drummer soil substrate, the concentrations of parent compounds at the end of the experiments were: HCB 0.90, PCNB 0.37, and PCP 0.12 ppm. (Tables 2, 56, 63, 101). In the flood water the parent residues were HCB 0.0008, PCNB 0.0002, and PCP 0.001 ppm (Tables 2, 61, 68, 107). The total ^{14}C residues in the air, HCB 0.014, PCNB 0.017, and PCP 0.078 ppm reflect the relative volatilities of the three fungicides plus their derivatives (Table 1).

In the corn plants, the parent residues were HCB 1.36, PCNB 1.08, and PCP 1.0 ppm (Tables 2, 57, 64, 102).

In the vole at the top of the food chain, the total body parent compound residues were: HCB 2.27, PCNB 0.051, and PCP 0.037 ppm (Tables 2, 5-, 66, 105). In the earthworms, the parent residues were: HCB 0.53, PCNB 0.15, and PCP 0.046 ppm, and in the pillbugs HCB 3.85, PCNB 0.51, and PCP 0.022 ppm (Tables 2, 58, 65, 104). The total residues in the snail were HCB 0.55, PCNB 1.60, and PCP 2.52, and in the fish HCB 1.13, PCNB 1.72, and PCP 1.76 ppm (Tables 2, 62, 69, 108) are clearly associated with increasing availability in the flood water leachates because of relative water solubility.

PESTICIDE ACCUMULATION AND DEGRADATION IN TERRESTRIAL BIOTA

There are important differences in the effects of the pesticides in the various animals used for evaluation. To take an overview of these, the pesticide accumulations have been averaged in the 5 common experimental animals used in this study, e.g. earthworm, pillbug, slug, salt-marsh caterpillar, and vole (Figure 13) and the pesticide degradations have been average for these 5 species (Figure 14). These comparisons have been restricted to data obtained from model ecosystem studies where substrates, application patterns and crops were identical and we have compared the data from the Drummer silty clay loam with the synthetic vermiculite substrate (Figure 13). The information shows that DDT and dieldrin are the most accumulative and persistent of the 15 pesticides in the bodies of the food chain animals. This is, of course, common knowledge from the real world situation where their use has been banned by EPA. Figure 13 also shows that parathion is substantially more accumulative than methyl parathion, and Figure 14 demonstrates that methyl parathion is much more rapidly degraded in animal bodies than parathion. A comparable situation is also shown by Figures 13 and 14 between DDT and methoxychlor. Thus it is clear that both accumulation and degradation should be viewed together to gain a composite picture of pesticide hazard to the total environment.

A similar type of comparison has been made in Figures 15 and 16 for a single animal species, the vole that is at the top of the food chain under evaluation. This comparison can be extended to include hexachlorobenzene (Table 105), phorate (Table 113), simazine (Table 130), trifluralin (Table 137), and 2,4,5-T ester (Table 146). These figures demonstrate that there is no sharp differentiation between "biodegradable" compounds such as captan, fonofos, methyl parathion, parathion, and methoxychlor; and "non-biodegradable" compounds such as aldrin, dieldrin, and DDT. Thus the property of biodegradability is relative and is expressed over a wide spectrum. Figure 16 also shows very clearly the importance of the *in vivo* formation of persistent degradative products, i.e. DDE from DDT and dieldrin from aldrin.

These data suggest the importance of comparisons of the environmental effects of pesticides not only over a range of species but also within species, and even within the organs of a single species, e.g. the carcass or liver of the vole as shown in Figure 12. Thus from Figure 15, it might appear that PCP and PCNB are likely to be as hazardous to the vole as aldrin. However, as shown in Figure 12, 68%, 66%, and 10% of the total body content of PCNB, PCP, and aldrin were found, respectively, in the gastrointestinal tracts of the test voles. Therefore, the corrected somatic concentration of aldrin is roughly two-fold greater than that of either PCNB or PCP. (Experimentally this comparison was done in the reverse order by determining the total body concentration by summation of the parts, i.e. Tables 41, 59, 66). Furthermore, as shown in Figure 8, 34% and 51% of the PCNB and PCP applications were lost by volatilization while virtually none of the aldrin was lost; and Table 3 shows clearly that PCNB and PCP are more degradable than dieldrin. Thus, it can be concluded that PCNB and PCP are potentially less hazardous environmentally than aldrin and dieldrin

The accumulation (or in examples where the pesticide was applied directly to the corn, the persistence) and degradation of the various pesticides in corn are shown in Figures 17 and 18. Figure 17 shows the concentration in the total plant and the proportions in shoot and root are indicated at the bottom of each bar. Figure 18 shows the relative degradability of these compounds in the corn plant. These data can be extended to include hexachlorobenzene (Table 104), phorate (Table 110), simazine (Table 126), and 2,4,5-T ester (Table 142). Plants grown in vermiculite treated with aldrin accumulated more total aldrin residue than plants grown in Drummer soil treated with aldrin (Figure 17). As shown in Figures 64 and 67, and Tables 110 and 118, corn grown in Drummer soil contained much less total ^{14}C residue (2.4% of total) than corn grown in Bloomfield soil (10.5% of total). Thus it is apparent that soil type definitely affects the quantity of pesticide accumulated by the plant.

CONCLUSIONS

We have analyzed above some of the more obvious conclusions from the wealth of more than 20,000 precise model ecosystem measurements as recorded in the body of this report. These analyses were based largely on questions that interested us as environmental toxicologists. Other problems for in depth study include the relationship of vapor pressure of the pesticide to loss from soil and transfer to air, the correlation of run-off and leaching with water solubility, relationship of octanol/H_2O partition with *in vivo* storage in invertebrates, fish, and in various tissues of the vole, and the intricate questions of the model ecosystem behavior of key pesticide degradation products. We plan to analyze some of these at our leisure.

In our evaluation we have included 15 important pesticides. This represents about 1% of all of the pesticide active ingredients presently used in U.S. agriculture. All of these ought to be studied by model ecosystem technology for better understanding and evaluation of their environmental effects. The results obtained in the present studies are closely linked with the "real world" by reason of our investigations of such widely used pesticides as DDT, aldrin, dieldrin, 2,4,5-T ester, simazine, trifluralin, captan, hexachlorobenzene, etc. We have shown that the model ecosystem results agree very closely with observations made in nature about such important subjects as biomagnification and food-chain transfer, leaching and run-off, soil persistence, and degradation pathways. Thus we may examine and predict with confidence the ecosystem effects of both proposed new pesticides and those old ones, such as RPAR'd products, about which there is considerable concern.

The terrestrial model ecosystem technology as developed under this grant is now workable, practical, and relatively inexpensive (see p. 292). The results are reproducible and the systems can be operated in any reasonably well equipped biological laboratory. We think it important that this type of investigation become a continuing part of the environmental evaluation of proposed new pesticides.

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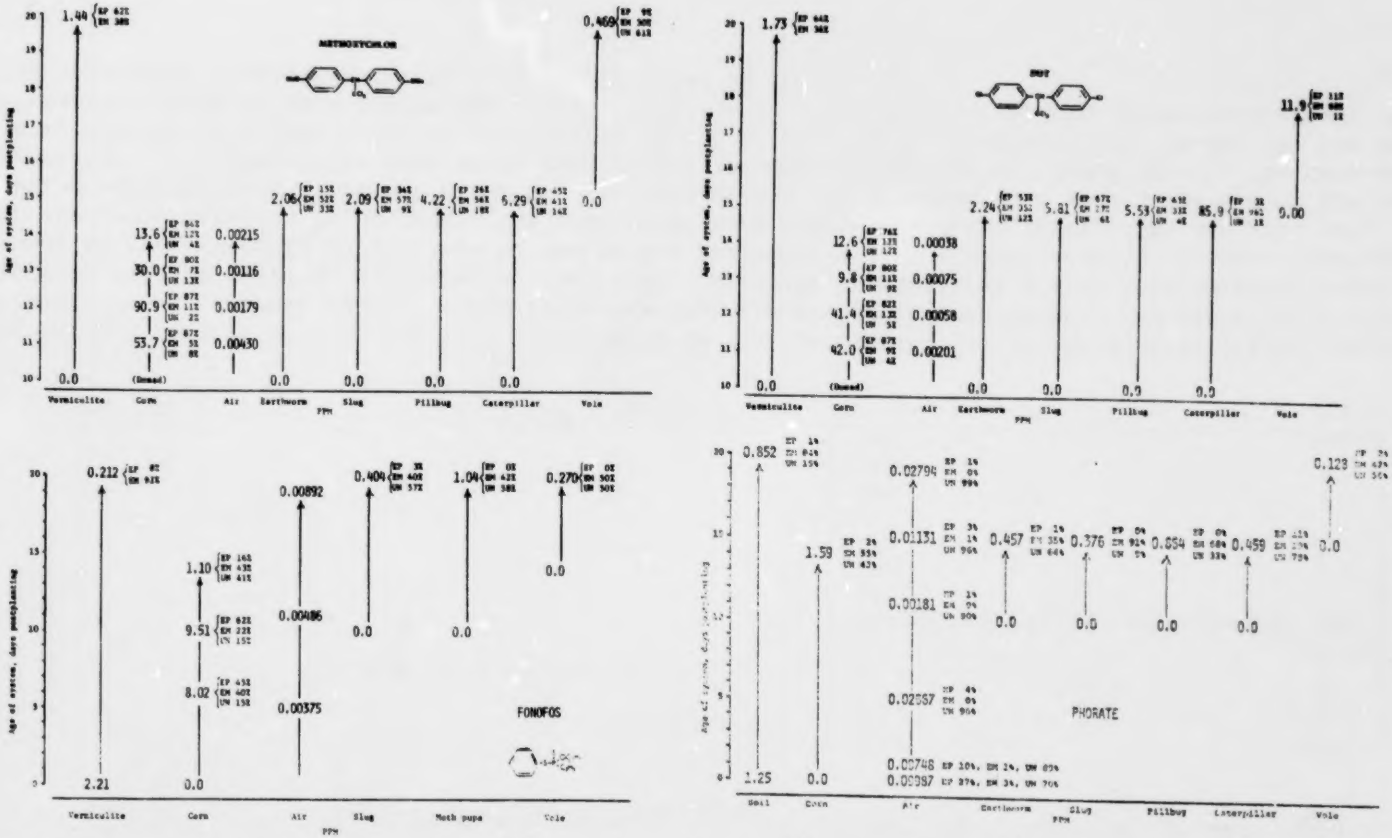

Figure 3. Summary of the fates of [^{14}C] methoxychlor, [^{14}C] DDT, and [^{14}C] fonofos in vermiculite, and [^{14}C] phorate in soil terrestrial model ecosystems. The total ^{14}C-residues are expressed as parent comp compound equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the substrates of the fonofos and phorate systems were treated at one lb AI/acre. On day 10, the corn foliage of the methoxychlor and DDT systems were treated randomly with one lb AI/acre. The invertebrates were added to each system on day 10 and the voles were added to the fonofos system on day 14 and to the other systems on day 15.

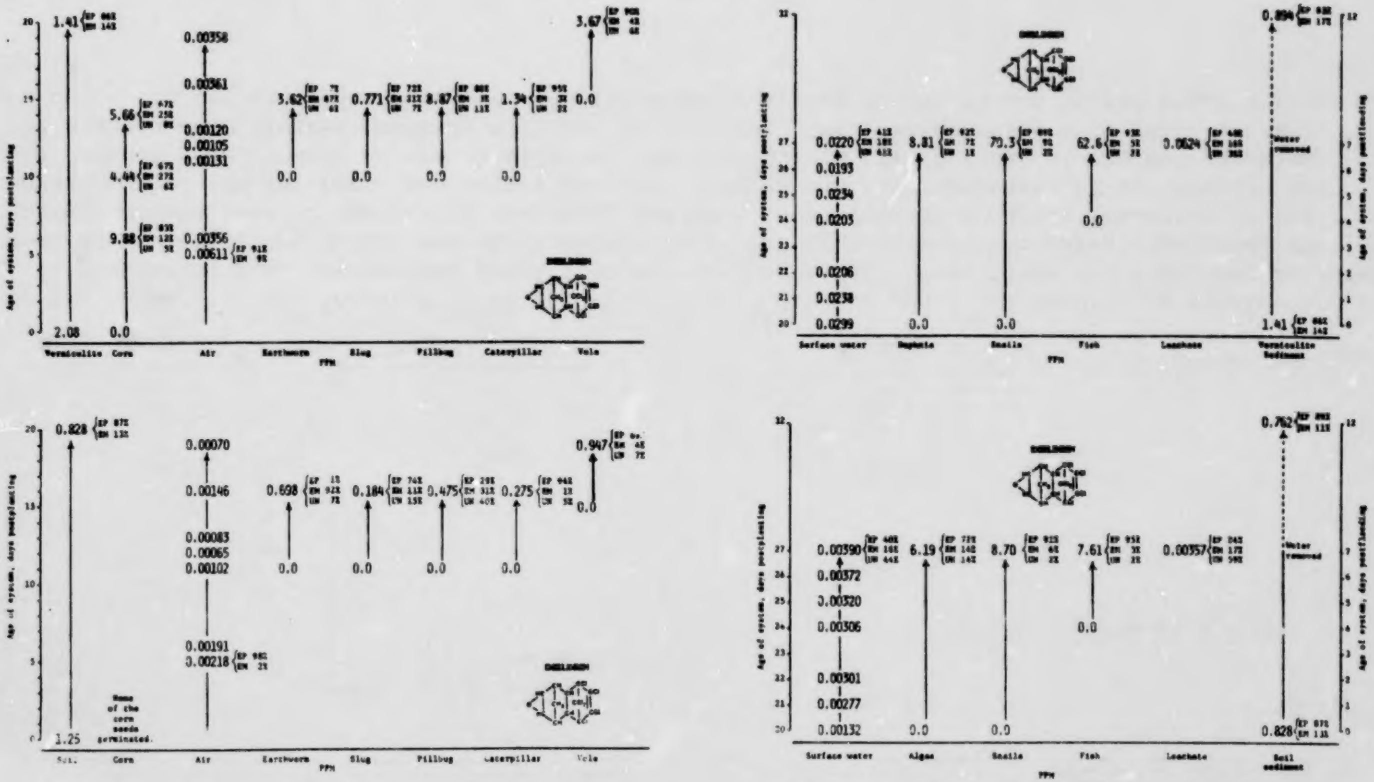

Figure 4. Summary of the fate of [^{14}C]dieldrin in the terrestrial (left) and aquatic (right) phases of vermiculite-terrestrial (upper) and soil-terrestrial (lower) model ecosystems. The total ^{14}C-residues are expressed as dieldrin equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted, and the vermiculite and soil were treated with dieldrin at one lb AI/acre. The soil system was drenched with water, instead of the usual sprinkling, and none of the corn seeds germinated; extraneous foliage was added later. The invertebrates and the vole were added to each system 10 and 15 days later, respectively. On day 20, the barren terrestrial phase of each system was flooded, and snails, Daphnia and mosquito larvae were added; the fish were added 4 days later; the algae originated in the soil.

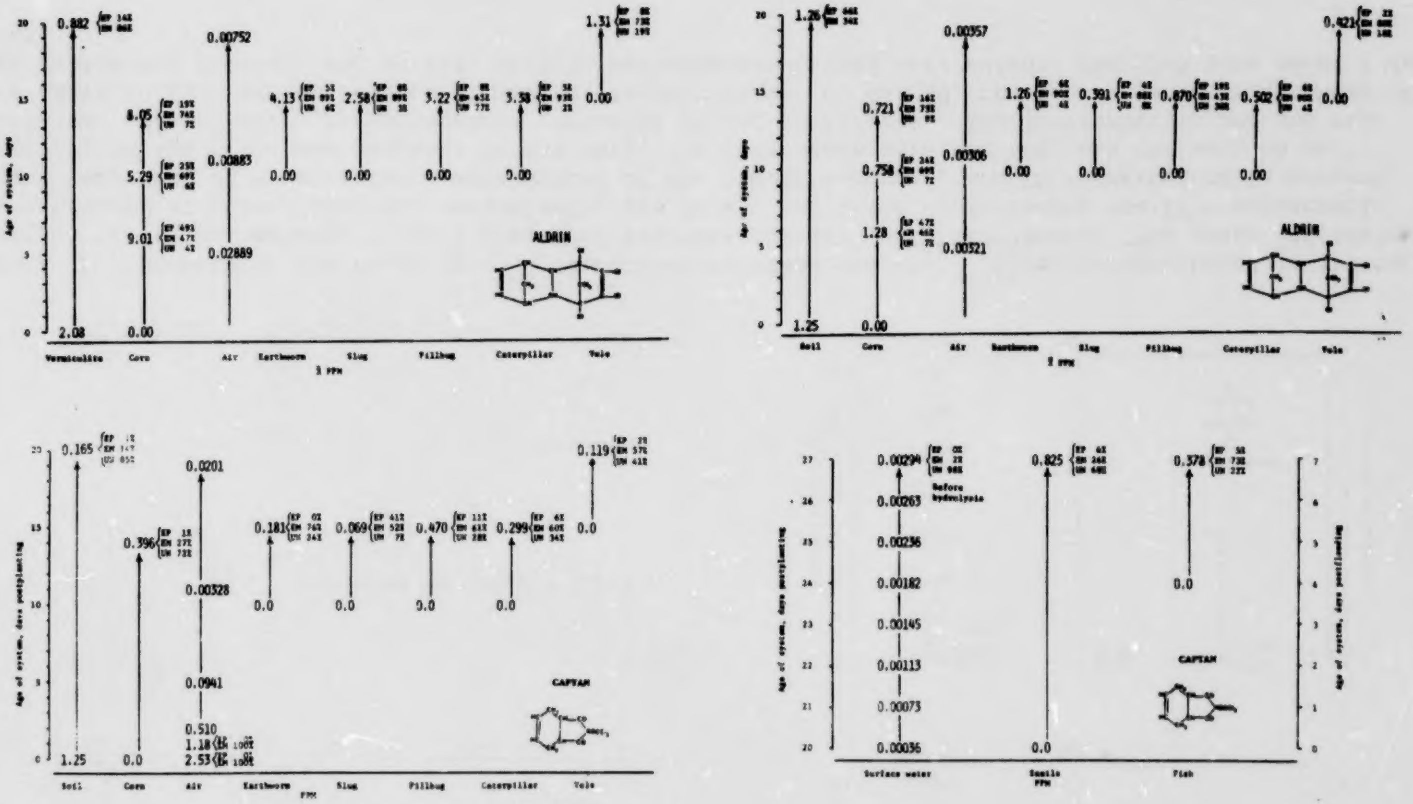

Figure 5 . Summary of the fates of $[^{14}C]$aldrin in vermiculite-terrestrial (upper left) and soil-terrestrial (upper right) model ecosystems and $[^{14}C]$captan in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as parent compound equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted, and the vermiculite and soil were treated with the appropriate pesticide at one lb AI/acre. The invertebrates and the vole were added to each system on days 10 and 15, respectively. On day 20, the barren terrestrial phase of the captan system was flooded, and snails, Daphnia and mosquito larvae were added; the fish were added 4 days later.

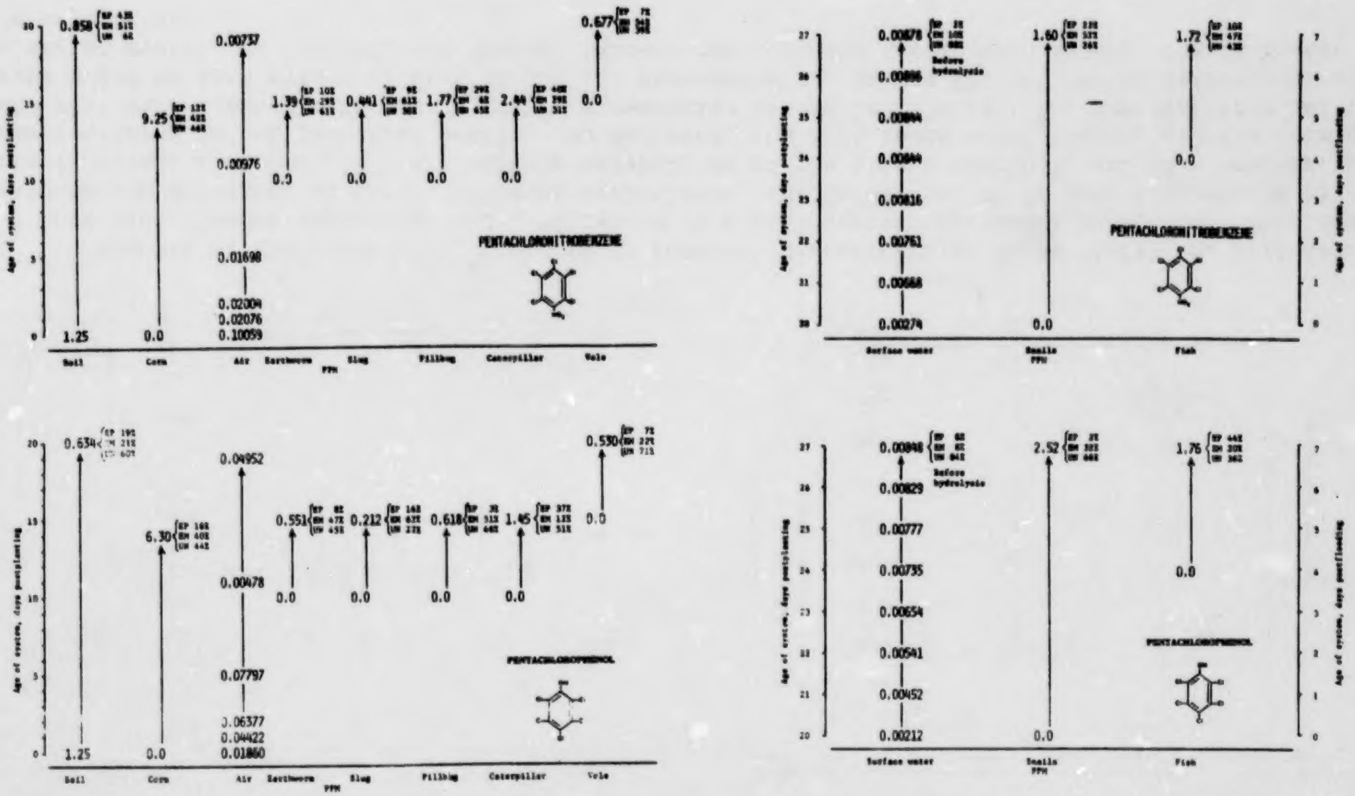

Figure 6. Summary of the fates of $[^{14}C]$pentachloronitrobenzene and $[^{14}C]$pentachlorophenol in the terrestrial (left) and aquatic (right) phases of soil-terrestrial model ecosystems. The total ^{14}C-residues are expressed as parent compound equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted, and the soil in each system was treated with the appropriate pesticide at one lb AI/acre. The invertebrates and the vole were added to each system on days 10 and 15, respectively. On day 20, the barren terrestrial phase of each system was flooded, and snails, Daphnia and mosquito larvae were added; the fish were added 4 days later.

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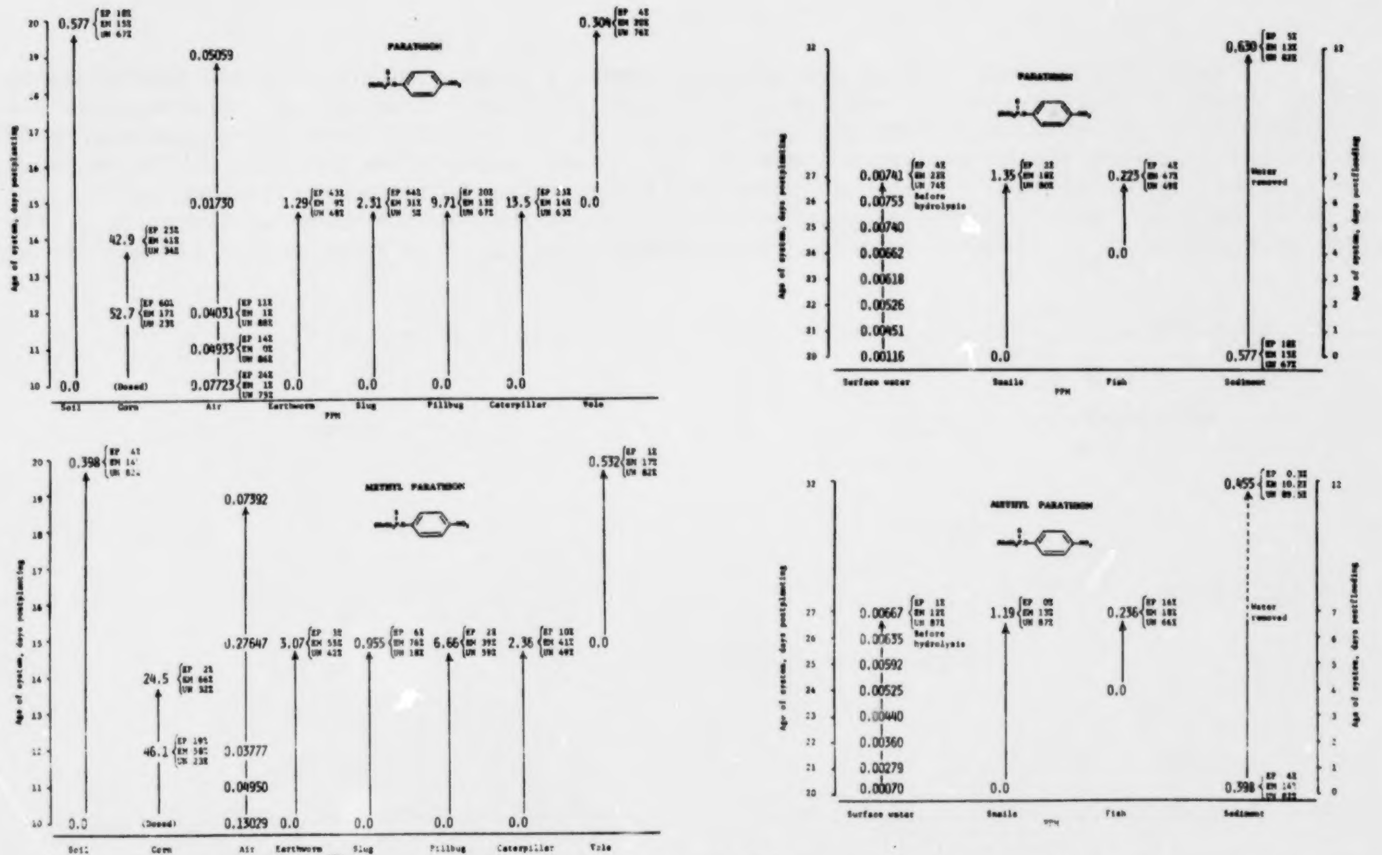


Figure 7. Summary of the fates of [^{14}C]parathion and [^{14}C]methyl parathion in the terrestrial (left) and aquatic (right) phases of soil-terrestrial model ecosystems. The total ^{14}C-residues are expressed as parent compound equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted. On day 10, the corn foliage was treated with the appropriate pesticide at one lb AI/acre, and the invertebrates were added to each system; the vole was added on day 15. On day 20, the barren terrestrial phase of each system was flooded, and snails, Daphnia and mosquito larvae were added; the fish were added 4 days later.

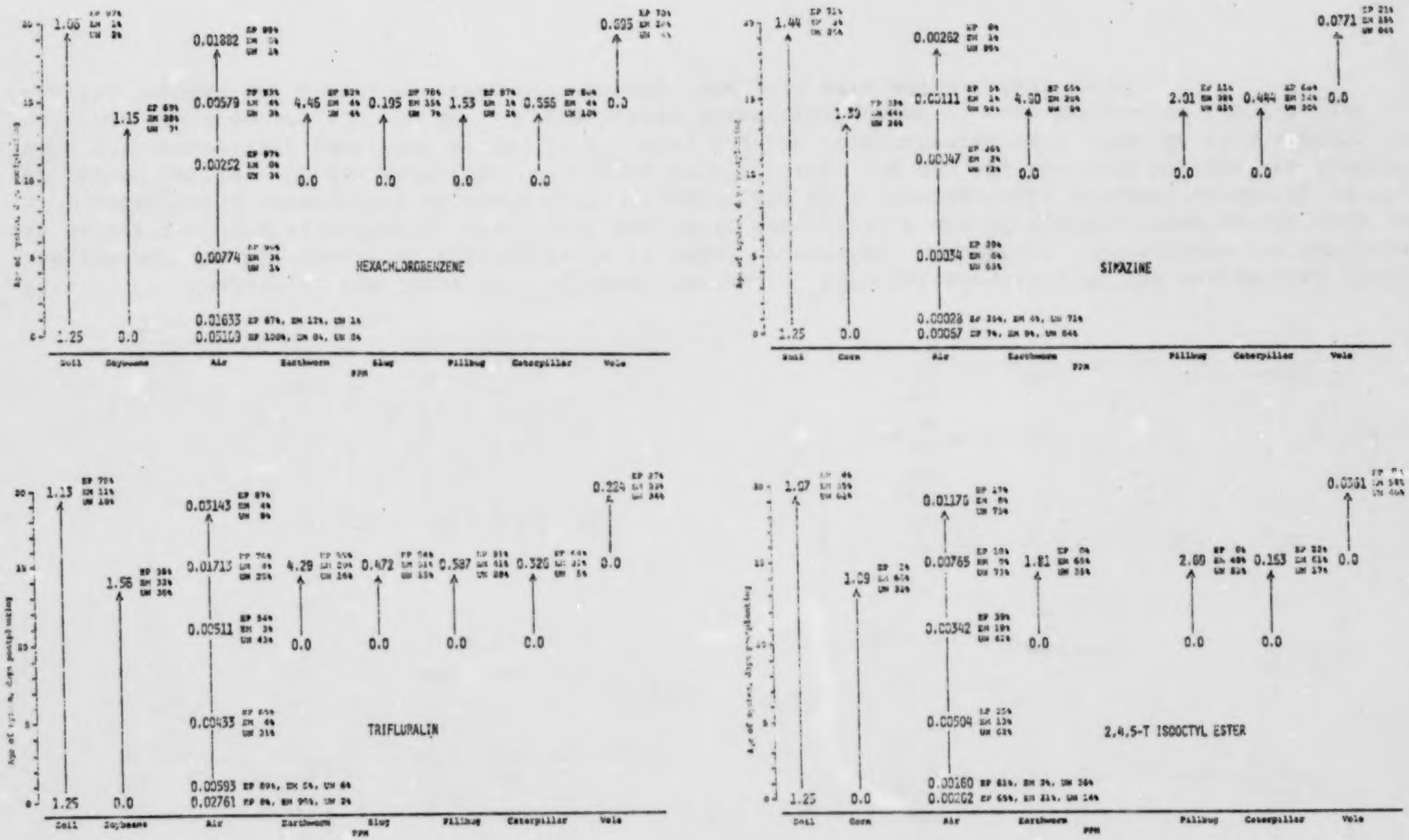


Figure 8. Summary of the fates of [^{14}C] hexachlorobenzene, (soybean system), [^{14}C] trifluralin (soybean system), [^{14}C] simazine (corn system, and [^{14}C] 2,4,5-trichlorophenoxyacetic acid, isooctyl ester (corn system); in the terrestrial phases of soil-terrestrial model ecosystems. The total ^{14}C residues are expressed as parent compound equivalents, ppm (w/w), and their subdivisions are EP=extractable parent compound, EM=extractable metabolites of the parent compound, and UN=unextractable products remaining in the processed sample. On day zero, the seeds were planted and the soil was treated at onelb. AI/acre. The invertebrates and the vole were added to each system 10 and 15 days later respectively.

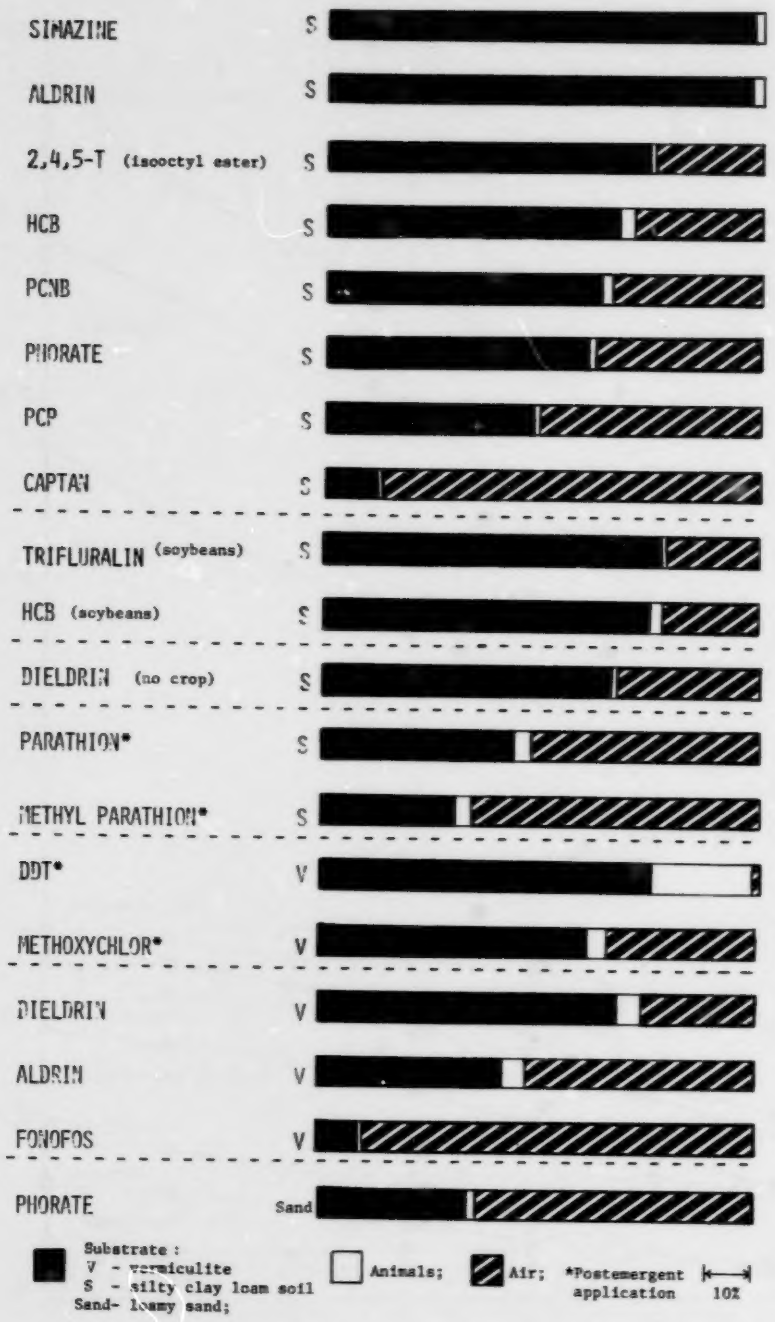


Fig. 9 .—Environmental distributions of the total ^{14}C-pesticidal residues (% of the applied dose) at the termination of the terrestrial phase of various model ecosystems dosed with a given pesticide. The plants, having been consumed and/or demolished by the animals, are not present as an entity at the termination of the system. (Calculations and more detailed distributions are presented in the text.)

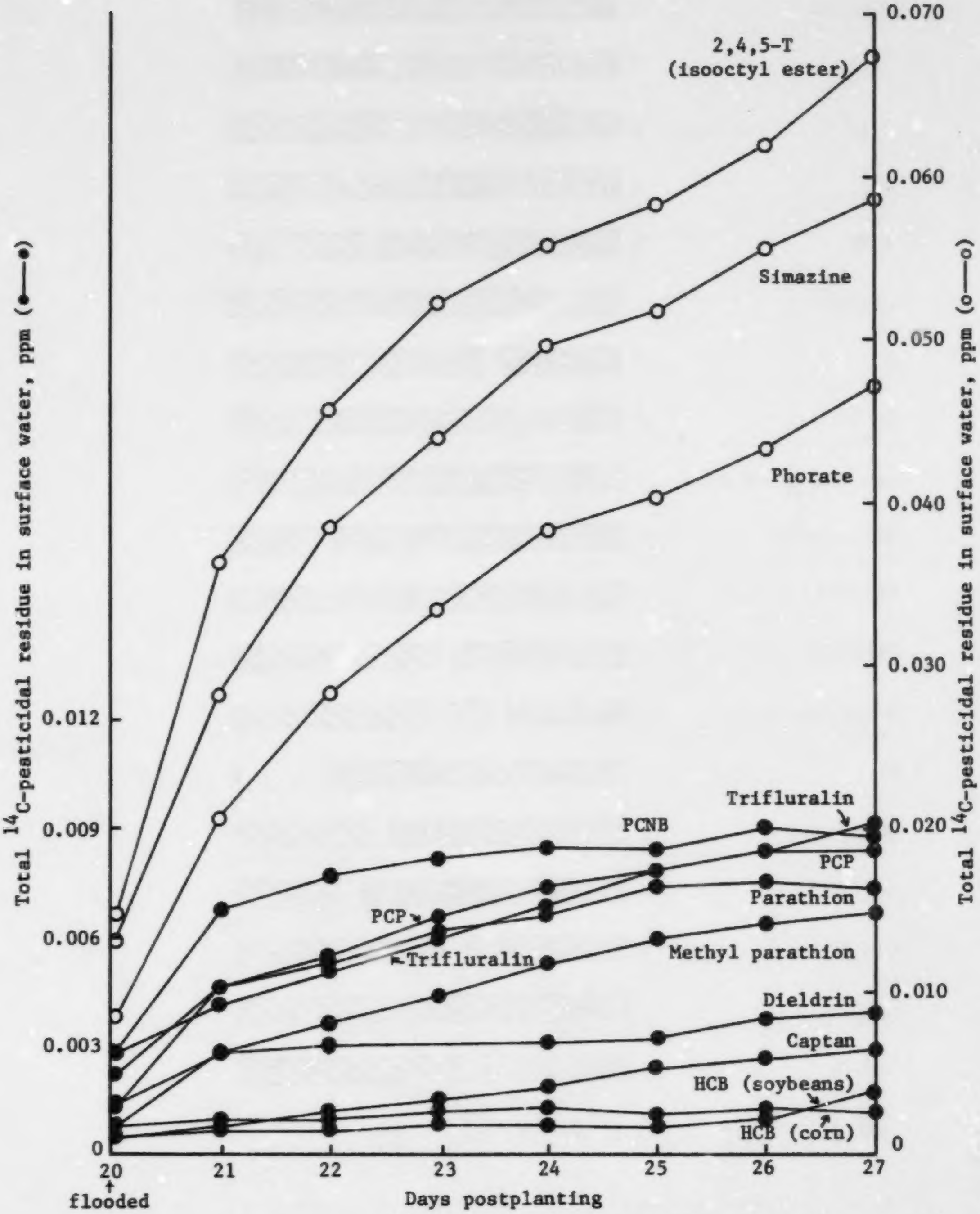


Fig. 10.—Translocations of total ^{14}C-pesticidal residues from soil (silty clay loam) to water. All systems were treated initially with the same absolute quantity of a given pesticide which in soil = 1.25 ppm. The two parathions were applied initially to crop foliage, instead of soil. No crop grew in the dieldrin system.

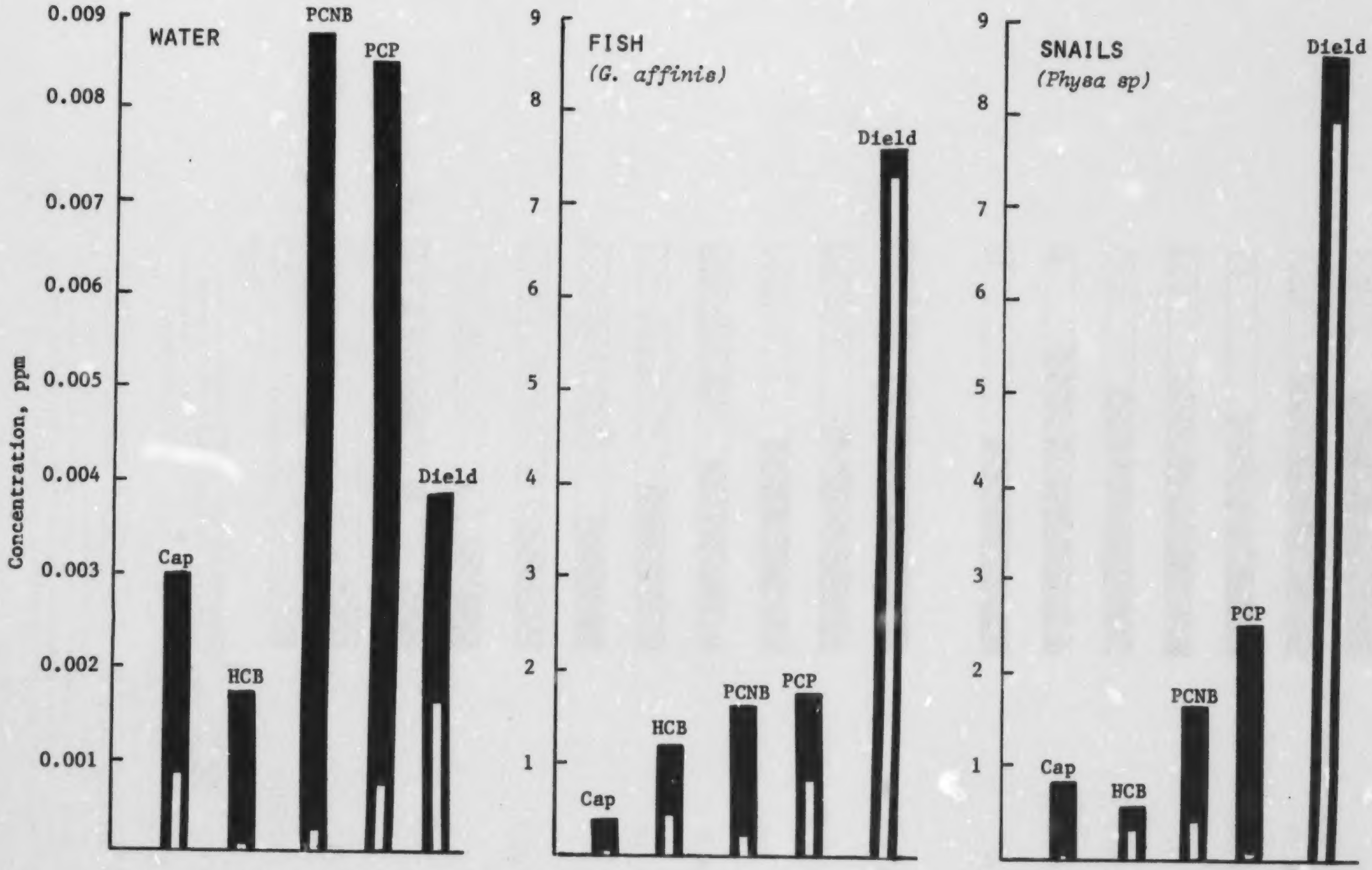


Fig. 11.—Total ^{14}C-pesticidal residues (black bars) and parent compounds (white bars) in the aquatic phase of a soil-terrestrial model ecosystem treated with $[^{14}C]$dieldrin compared with those treated with fungicides. The barren terrestrial phases were flooded 20 days after dosing the soils. The snails were added at the time of flooding, and the fish were added 4 days later; water, fish and snails were analyzed 7 days postflooding.

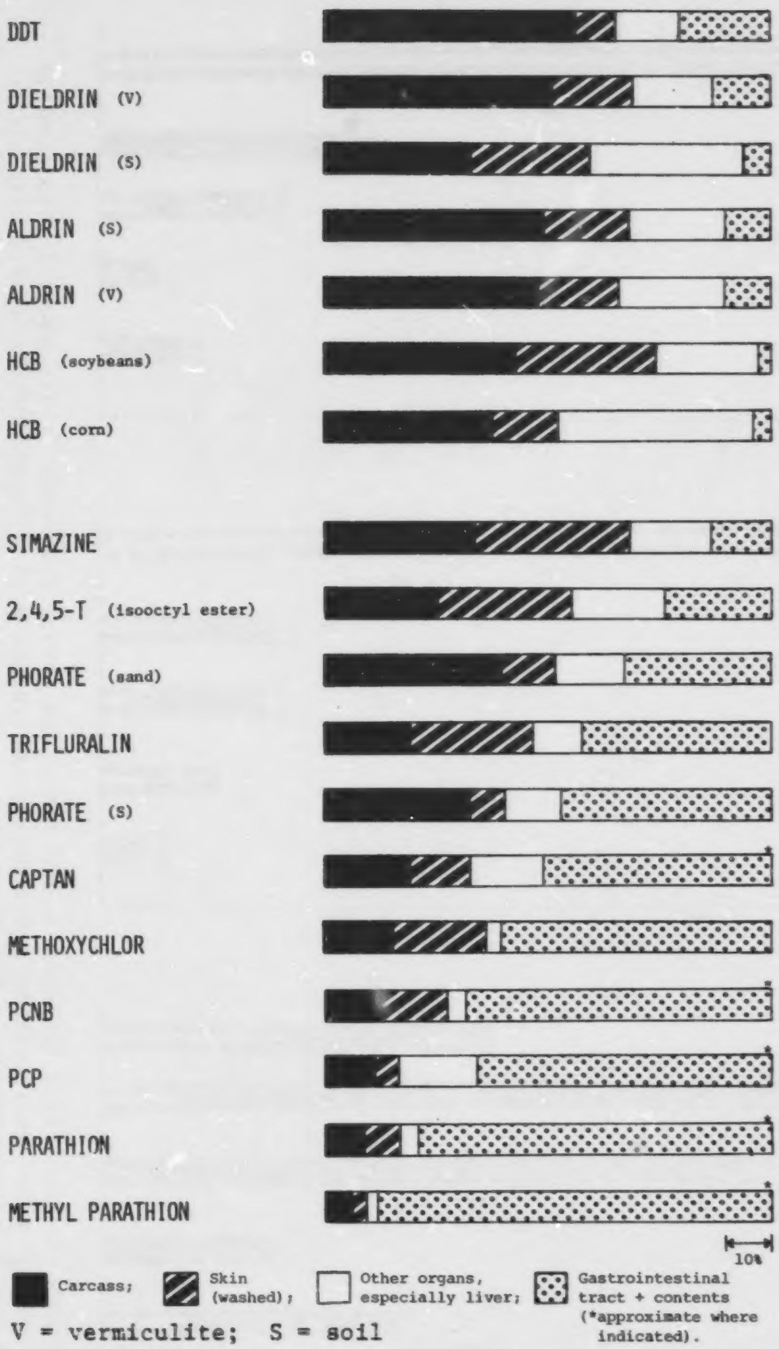


Fig. 12—Proportions (%) of the total ^{14}C-pesticidal residue (µg) detected in the entire vole located in various organs. These are distributions of actual quantities, not concentrations. The carcass is the body minus its viscera and skin; it consists predominately of muscle and bone. (Detailed distributions are described in the text and are compared with the relative masses of the organs.)

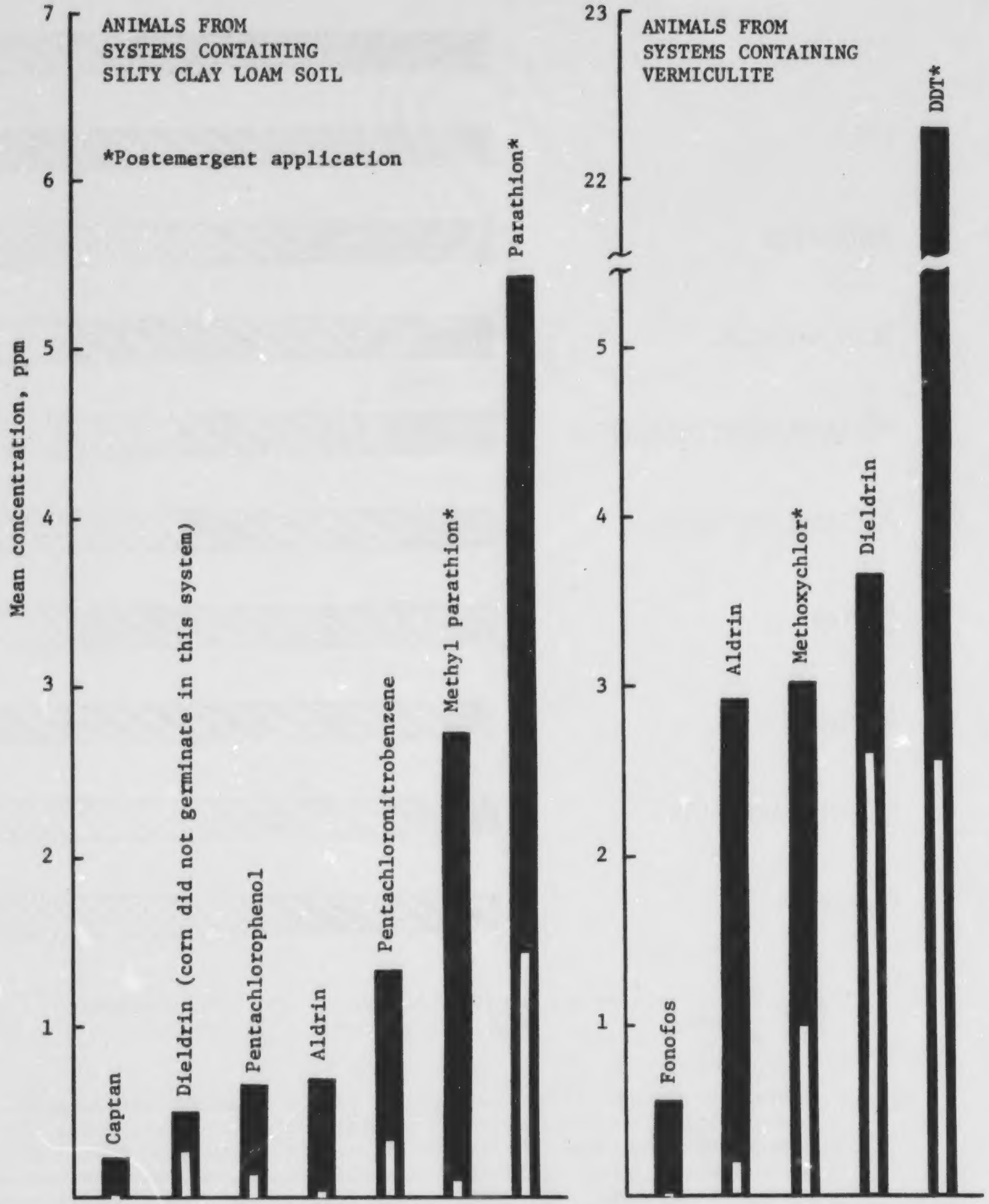


Fig. 13.—Accumulations of total ^{14}C-pesticidal residues (black bars) and parent compounds (white bars) in terrestrial animals as averaged over 5 species (earthworms, slugs, pillbugs, caterpillars, and voles) from model ecosystems containing either a vermiculite substrate or a silty clay loam soil. The animals were analyzed after a 5-day exposure within a given model ecosystem. Each system was dosed with a single pesticide at a rate simulating one lb AI/acre; the mode of application was either preemergent to substrate or postemergent to foliage, as indicated.

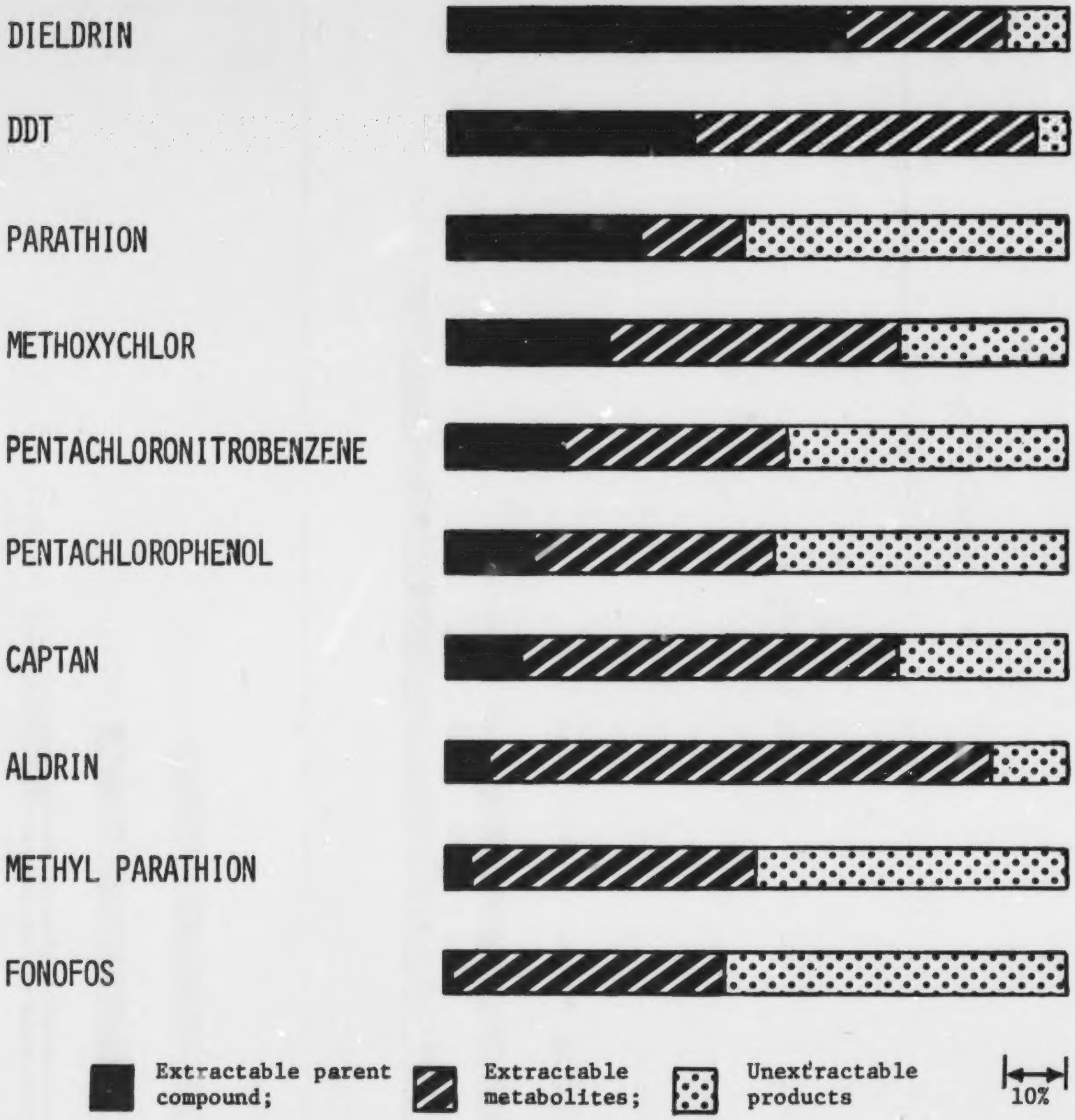


Fig.14 .—Mean proportions (%) of extractable parent compound, extractable metabolites, and unextractable products detected in the total ^{14}C-pesticidal residues in terrestrial animals as averaged over 5 species (earthworms, slugs, pillbugs, caterpillars, and voles) from terrestrial model ecosystems; only the dieldrin residue was predominately parent compound. (Degradation within each species and the nature of the metabolites is described in the text.)

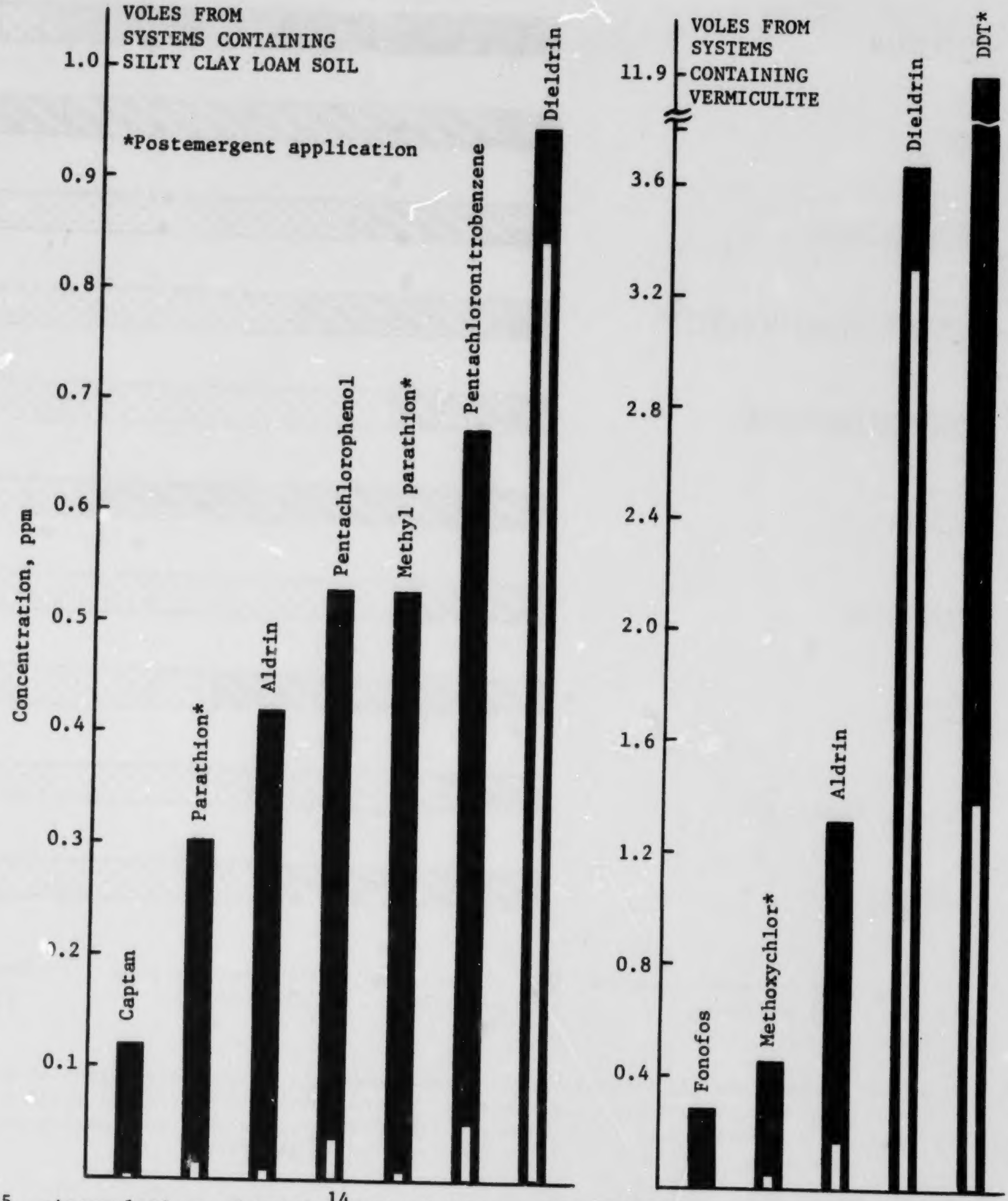


Fig. 15.—Accumulations of total ^{14}C-pesticidal residues (black bars) and parent compounds (white bars) in voles (entire body) from model ecosystems containing either a vermiculite substrate or a silty clay loam soil. The voles were analyzed after a 5-day exposure within a given model ecosystem. Each system was dosed with a single pesticide at a rate simulating one lb AI/acre; the mode of application was either preemergent to substrate or postemergent to foliage, as indicated. No corn germinated in the soil system treated with dieldrin; the system was drenched with water instead of normal sprinkling.

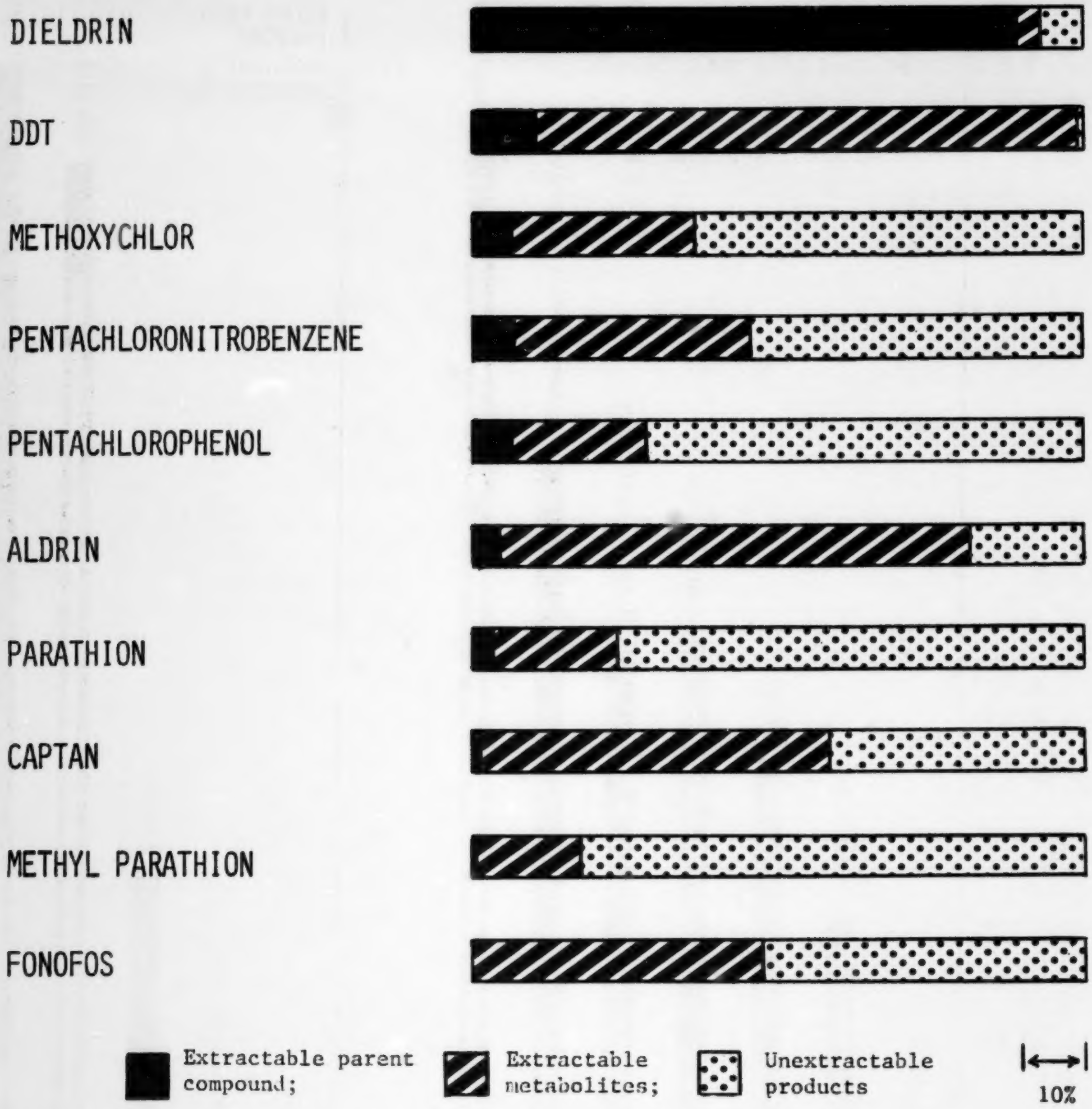


Fig.16 .— Proportions (%) of extractable parent compound, extractable metabolites, and unextractable products detected in the total ^{14}C-pesticidal residues in the entire vole body. (Degradation within individual vole organs and the nature of the metabolites is described in the text.)

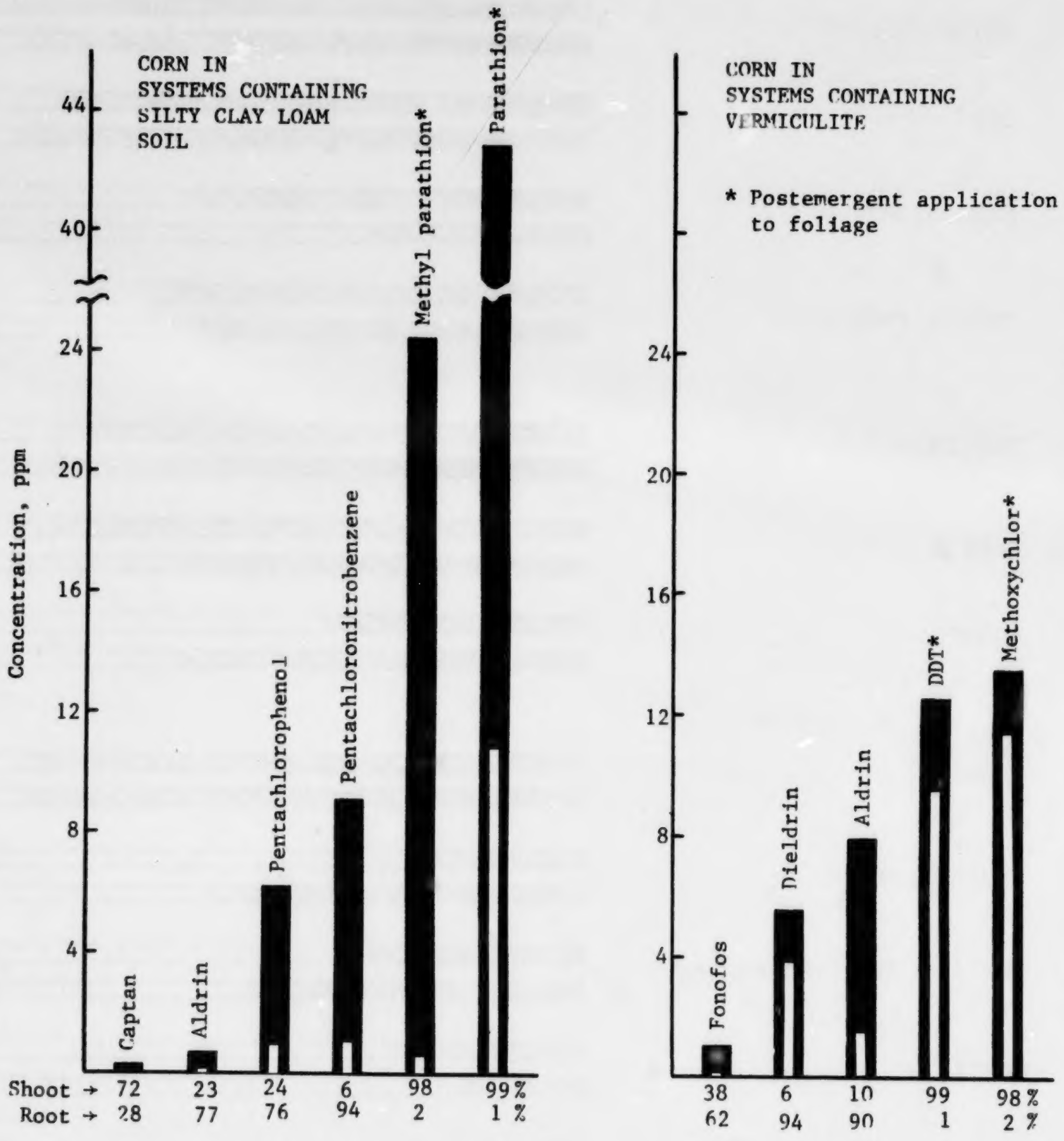
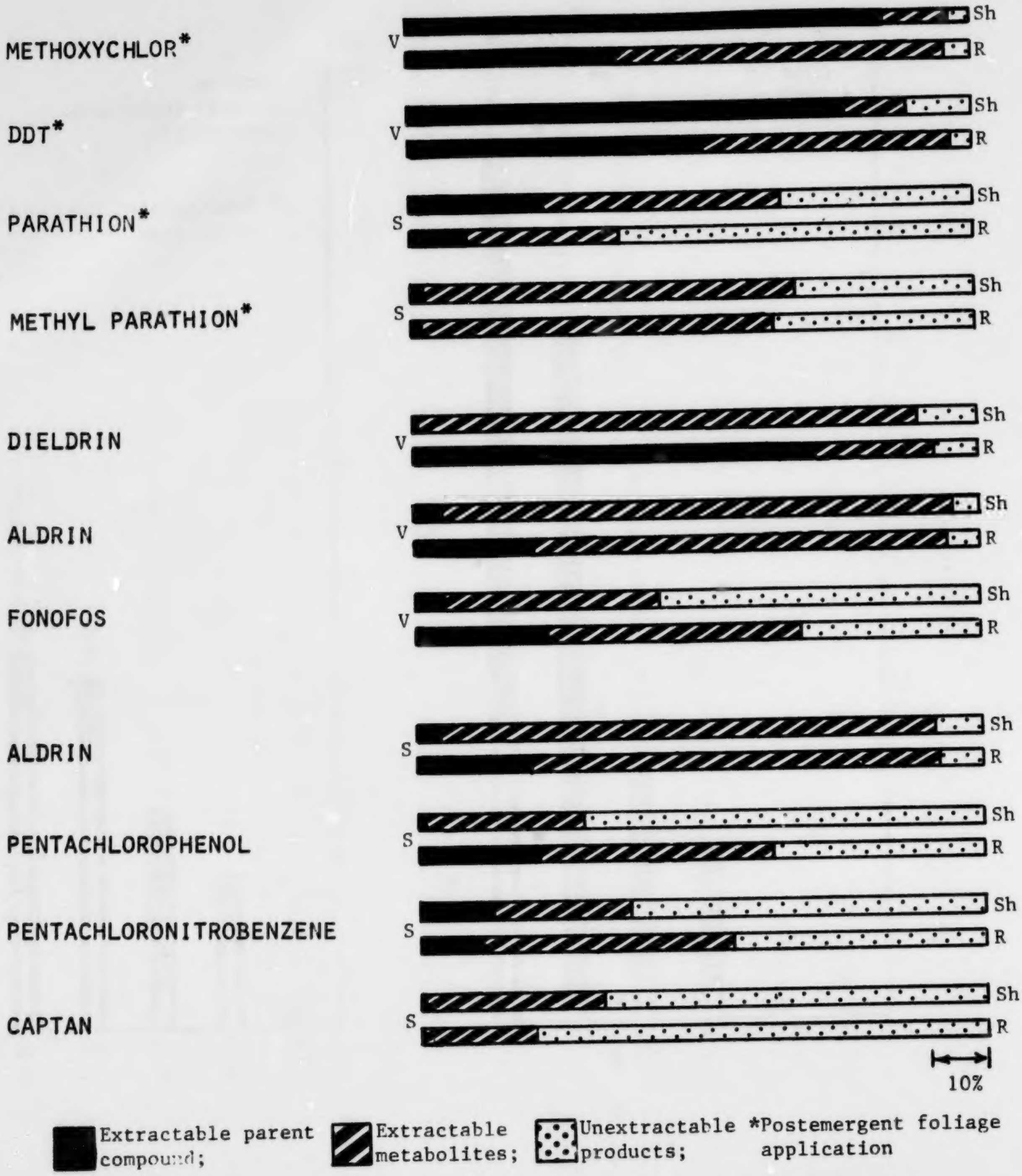


Fig. 17.—Concentrations of total ^{14}C-pesticidal residues (black bars) and parent compounds (white bars) in entire corn plants 14 days postplanting, and the proportions (%) of the residues (μg, not concentration) located in shoots and roots. Postemergent applications directly to corn foliage were made 10 days postplanting, and preemergent applications to soil were conducted at the time of planting. Each system was dosed with a single pesticide at a rate simulating one lb AI/acre.

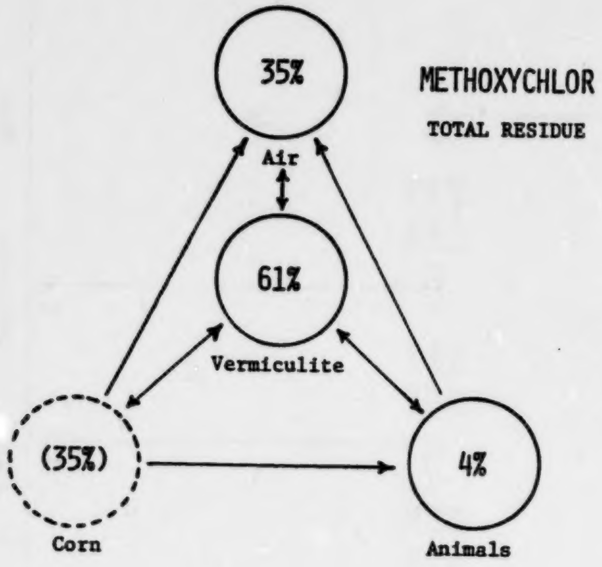


Sh = corn shoots; R = corn roots; V = vermiculite; S = silty clay loam soil.

Fig. 18 .—Proportions (%) of extractable parent compound, extractable metabolites, and unextractable products detected in the total ^{14}C-pesticidal residues from corn shoots and roots. Plants dosed by postemergent application were analyzed 4 days after dosing, and plants from systems treated with a preemergent soil application were analyzed 14 days after dosing.

APPENDIX

Detailed Fates of
Individual Pesticides



Calculation of the above estimates:

Ecosystem component	Total maximum mass, g: (No.)	$\overline{X}$ mass	= total	Mean concentration, µg/g	Total residue, µg: (mass)(conc.)	Total residue as a % of applied dose (5000 µg)
Earthworms	(10)	2.78	= 27.8	2.06	57.3	1.1
Slugs	(10)	3.46	= 34.6	2.09	72.3	1.4
Pillbugs	(20)	0.0915	= 1.83	4.22	7.72	0.2
Caterpillars	(10)	0.785	= 7.85	6.29	49.4	1.0
Vole	(1)	26.2	= 26.2	0.469	12.3	0.2
Animal total (I)			98.3		109	3.9
Corn[a]	(44)	2.95	= 130	13.6	1768	35.4
Vermiculite (II)	(1)	2122	= 2122	1.44	3056	61.1
Air				[5000 µg-(I+II)] =	1745	34.9

[a] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the system.

Fig. 19.-Terminal environmental distribution of $[^{14}C]$methoxychlor plus metabolites in a vermiculite-terrestrial model ecosystem.

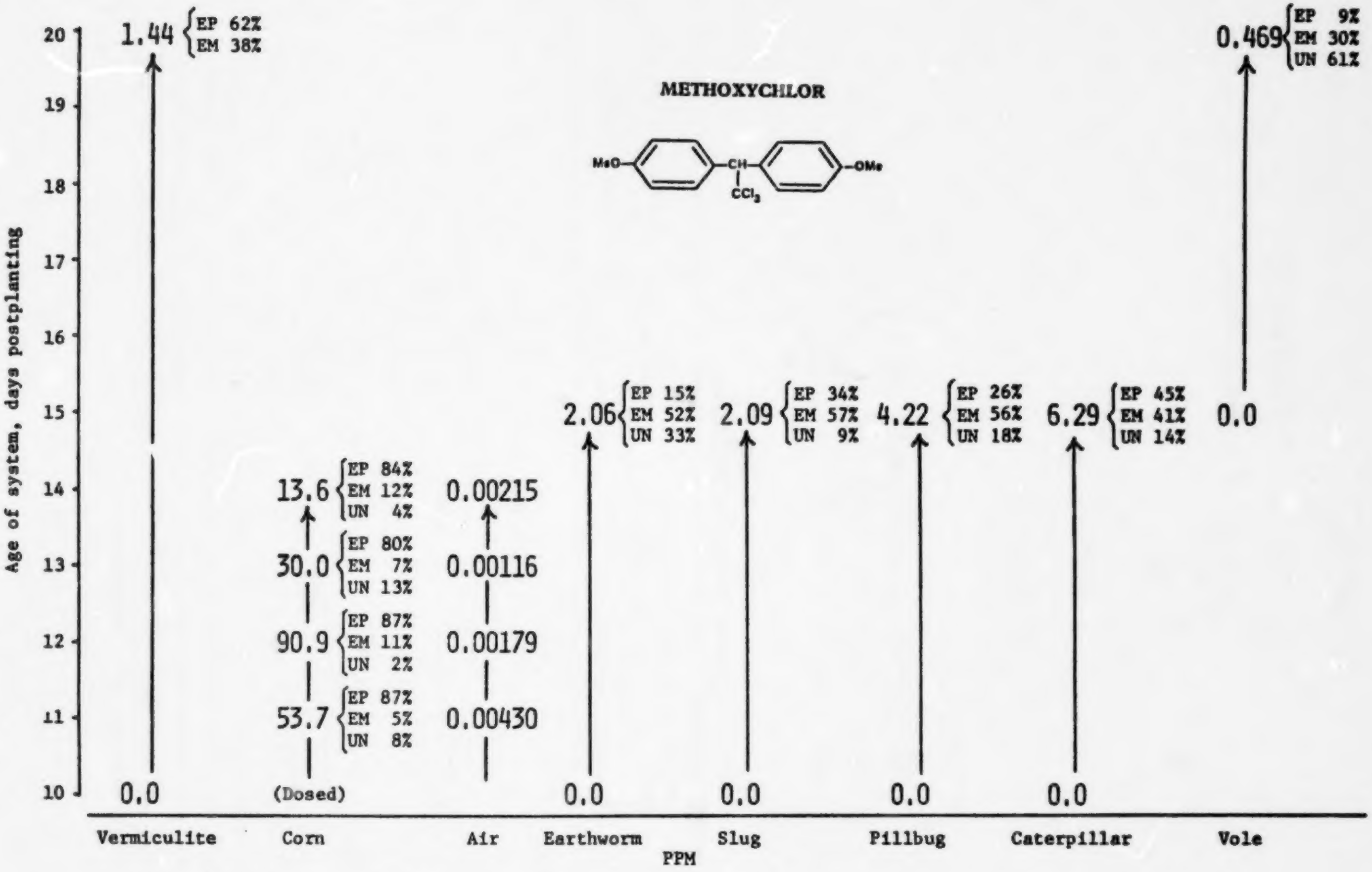


Fig. 20.—Summary of the fate of [^{14}C]methoxychlor in a vermiculite-terrestrial model ecosystem. The total ^{14}C-residues are expressed as methoxychlor equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted. On day 10, the corn foliage was treated randomly with methoxychlor at one lb AI/acre, and the invertebrates were added. On day 15 the vole was added.

Table 4.—Concentrations of methoxychlor and degradation products in the vermiculite substrate ("soil") of a terrestrial ecosystem 10 days after carefully applying the methoxychlor to the corn foliage

Compound	Rf[a]	Methoxychlor equivalents, ppm	
		Acetone extract	Methanol[b] extract
I[c]	.95		<0.001
M-DDE	.80	0.050	0.001
M[d]	.71	0.878	0.008
M-DDD	.63	0.010	
II	.27	0.022	0.001
III	.23	0.022	0.002
mono-OH	.18	0.121	0.009
IV	.14	0.041	
di-OH	.05	0.143	0.013
V	.00	0.101	0.017
Total ^{14}C		1.388	0.051
Biosample wt (g)		100.00	100.00

[a] Silica gel GF-254, petroleum ether : ether, 17:3 by volume.

[b] The methanol extract is from the sample previously extracted with acetone.

[c] Roman numerals = unknown compounds.

[d] Methoxychlor.

Table 5.—Concentrations of methoxychlor and degradation products in corn grown in a terrestrial model ecosystem.

		Methoxychlor equivalents, ppm, at indicated postplanting age											
		11 Days			12 Days			13 Days			14 Days		
Compound	R_f[a]	Root	Shoot	Entire plant	Root	Shoot	Entire plant	Root	Shoot	Entire plant	Root	Shoot	Entire plant
I[b]	.97	0.212		0.081	0.416		0.230	0.008		0.003	0.216	0.192	0.204
M-DDE	.80		3.930	2.452	0.024	13.731	6.982		2.320	1.267		1.055	0.504
M[c]	.71	0.055	75.536	47.153	1.006	155.039	79.247	0.161	43.868	24.012	0.246	23.612	11.418
M-DDD	.63		0.532	0.332	0.218	1.095	0.676		0.178	0.097	0.048	0.192	0.117
II	.39		0.215	0.134		0.758	0.385			0.061		0.064	0.031
mono-OH	.18	0.011	0.668	0.421	0.021	0.884	0.461	0.006	0.112	0.171	0.018	0.408	0.204
di-OH	.05		0.136	0.085	0.009	0.421	0.218	0.018	0.309	0.069	0.015	0.140	0.075
III	.00	0.014	0.725	0.458	0.067	2.148	1.128	0.022	0.112	0.454	0.089	1.107	0.576
Extractable ^{14}C		0.292	81.742	51.116	1.761	174.076	89.327	0.215	0.814	26.134	0.632	26.770	13.129
Unextractable ^{14}C		0.019	4.366	2.594	0.069	3.219	1.544	0.036	6.822	3.824	0.032	0.978	0.499
Grand Total ^{14}C		0.311	86.108	53.710	1.830	177.295	90.871	0.251	7.636	29.958	0.664	27.748	13.628
Biosample wgt. (g)		0.73773	1.07000	1.80773	0.97911	0.82165	1.80076	1.18650	1.42100	2.60750	1.35233	1.30851	2.6

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[a] Silica Gel GF-254, Petroleum Ether: Ether, 17:3 by volume.

[b] Roman numerals = unknown compounds.

[c] Methoxychlor.

Table 6.—Concentrations of methoxychlor and degradation products in invertebrates after a 5-day exposure in a terrestrial model ecosystem

		Methoxychlor equivalents, ppm[a]			
Compound	R_f[b]	*Lumbricus* (worm)	*Limax* (slug)	*Armadillidium* (pillbug)	*Estigmene* (caterpillar)
I[c]	1-.77	0.031			
II	.94				0.089
III	.91		0.019		
M-DDE	.80	0.055	0.050	0.055	0.526
IV	.77-.49	0.209			
M[d]	.71	0.316	0.700	1.102	2.829
M-DDD	.63		0.099	0.208	0.038
mono-OH	.18		0.209	0.130	0.155
V	.13	0.121			
di-OH	.05	0.126	0.115	0.186	0.425
VI	.00	0.534	0.701	1.781	1.358
Extractable ^{14}C		1.392	1.893	3.462	5.420
Unextractable ^{14}C		0.665	0.192	0.755	0.866
Total ^{14}C		2.057	2.085	4.217	6.286
Average biosample wt (g)		2.78104	3.45632	0.09154	0.78475

[a] Average of triplicate determinations.

[b] Silica Gel GF-254, Petroleum Ether: Ether, 17:3 by volume.

[c] Roman numerals = unknown compounds.

[d] Methoxychlor.

Table 7.—Concentrations of methoxychlor and degradation products in the prairie vole after a 5-day exposure in a terrestrial model ecosystem.

		Methoxychlor equivalents, ppm						
Compound	R_f [a]	Stomach	Large intestine	Skin	Small intestine	carcass	Internal[b] organs	Body[c] totals
I[d]	.97			0.106	0.001	0.009	0.009	0.019
II	.95			0.101	0.002	0.010	0.006	0.019
III	.94						0.004	
IV	.93-.80						0.007	0.001
M-DDE	.80			0.035		0.005		0.007
V	.80-.68						0.011	0.001
M[e]	.71	0.087	0.009	0.212	0.015	0.013		0.041
VI	.63-.39						0.014	0.001
VII	.24		0.004					0.001
VIII	.22	0.015	0.002					0.001
IX	.39-.05						0.009	0.001
mono-OH	.18	0.019	0.006	0.021	0.007	0.010		0.010
X	.12	0.014			0.006			0.001
di-OH	.05	0.080	0.009	0.054	0.023			0.014
XI	.00-.05						0.004	
XII	.00	0.541	0.127	0.020	0.041	0.025		0.067
Extractable ^{14}C		0.756	0.157	0.549	0.095	0.072	0.064	0.184
Unextractable ^{14}C		1.011	0.876	0.205	0.373	0.082	0.078	0.285
Total ^{14}C		1.767	1.033	0.754	0.468	0.154	0.142	0.469
Biosample wt (g)		1.48535	3.91635	3.42487	1.57405	12.65070	2.67095	

[a] Silica Gel GF-254, Petroleum Ether: Ether, 17:3 by volume.

[b] Internal organs include heart, parotid gland, lungs, kidneys and adrenals, uterus, tongue, mammary gland, liver and brain; extracts of these organs were combined and chromatographed as a single sample.

[c] Body totals were calculated using the live wet weight, 26.220 g.

[d] Roman numerals = unknown compounds.

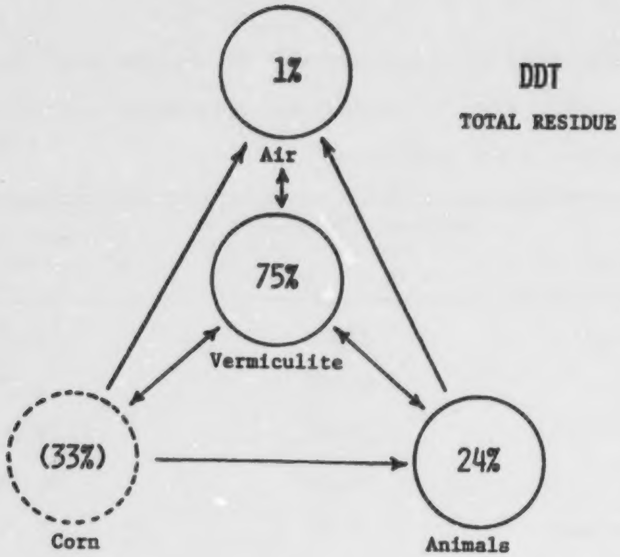
[e] Methoxychlor.

Table 8.—Relative affinities of 14 body-parts of the prairie vole[a] for [^{14}C]methoxychlor plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Large intestine + contents	32.86	15.22
Stomach + contents	21.34	5.77
Skin	21.02	13.31
Carcass[b]	15.70	49.18
Small intestine + contents	5.98	6.12
Liver	1.23	4.51
Heart	0.43	0.63
Tongue	0.35	0.37
Kidneys + adrenals	0.32	1.08
Uterus	0.20	0.18
Mammary glands	0.17	0.25
Lungs	0.16	0.80
Parotid glands	0.15	0.56
Brain	0.09	2.01
	100.00	99.99

[a] Vole from a vermiculite-terrestrial model ecosystem treated with [^{14}C]methoxychlor.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.



Calculation of the above estimates:

Ecosystem component	Total maximum mass, g:			Mean concentration, µg/g	Total residue, µg:	Total residue as a % of applied dose (5000 µg)
	(No.)	$\overline{X}$ mass	= total		(mass)(conc.)	
Earthworms	(10)	3.21	= 32.1	2.24	71.9	1.4
Slugs	(10)	2.23	= 22.3	5.81	130	2.6
Pillbugs	(20)	0.0584	= 1.17	5.53	6.5	0.1
Caterpillars	(10)	0.818	= 8.18	85.9	703	14.1
Vole	(1)	25.32	= 25.32	11.9	302	6.0
Animal total (I)			89.1		1213	24.2
Corn[a/]	(44)	2.95	= 130	12.6	1638	32.8
Vermiculite (II)	(1)	2160	= 2160	1.73	3737	74.7
Air				[5000 µg-(I+II)] =	50	1.0

[a/] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the system.

Fig. 21.-Terminal environmental distribution of [^{14}C]DDT plus metabolites in a vermiculite-terrestrial model ecosystem.

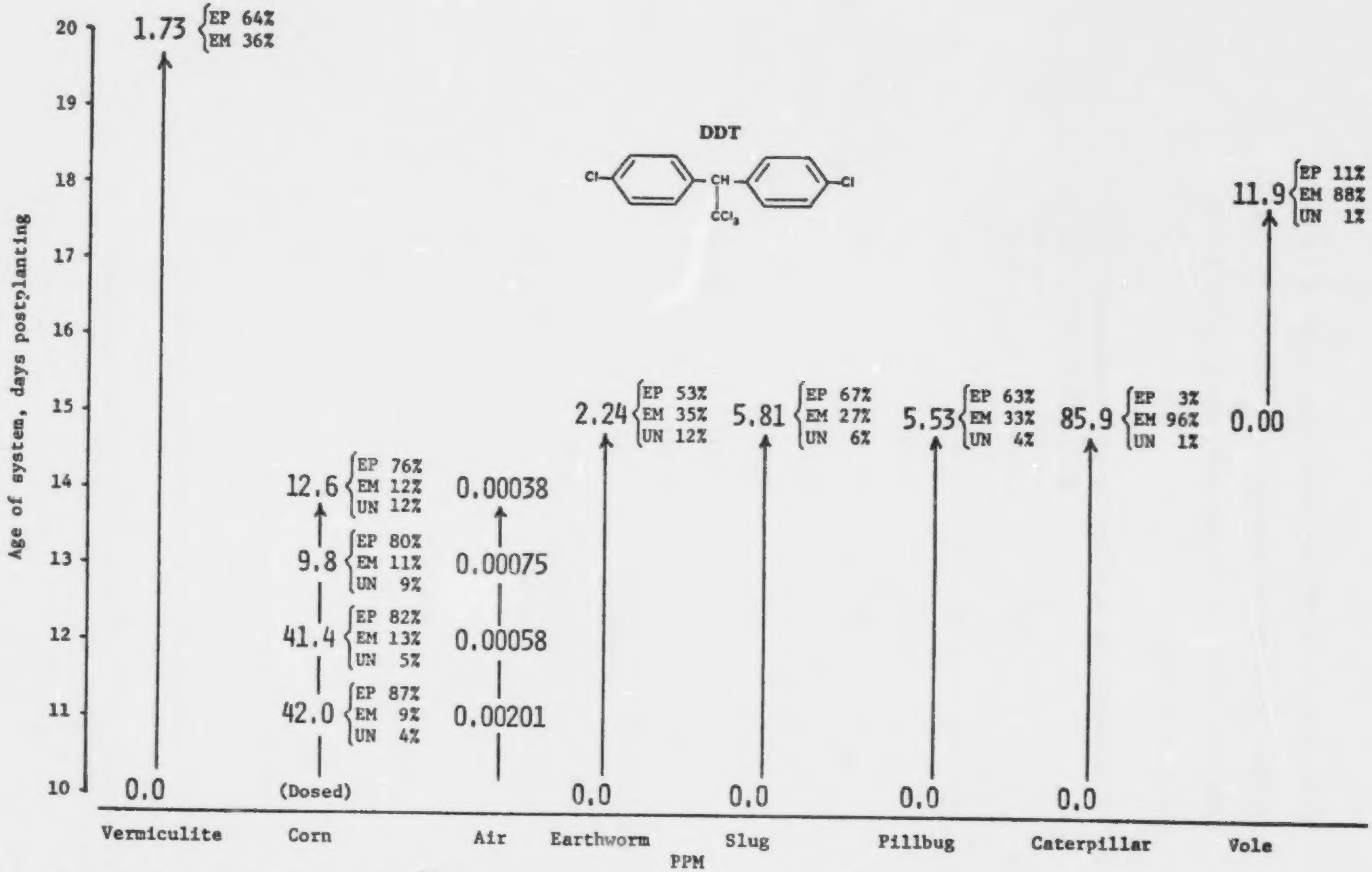


Fig. 22.—Summary of the fate of [^{14}C]DDT in a vermiculite-terrestrial model ecosystem. The total ^{14}C-residues are expressed as DDT equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted. On day 10, the corn foliage was treated randomly with DDT at one lb AI/acre, and the invertebrates were added. On day 15, the vole was added; it died 3 days later.

Table 9.—Concentrations of DDT and degradation products in the vermiculite substrate ("soil") of a terrestrial model ecosystem 10 days after carefully applying the DDT to the corn foliage.

		DDT equivalents, ppm	
Compound	R_f[a]	Acetone extract	Methanol[b] extract
DDE	.90	0.167	0.001
DDMU	.84	0.026	
DDT	.80	1.115	0.002
DDMS	.70	0.042	
DDD	.63	0.080	
I[c]	.45	0.011	0.002
II	.42	0.055	
III	.17	0.007	
IV	.13	0.007	
V	.10		0.001
DDA	.02	0.019	0.004
VI	.00	0.179	0.011
Total ^{14}C		1.708	0.021
Biosample wgt. (g)		100.000	100.000

[a] Silica Gel GF-254, Hexane: Diethyl ether, 24:1 by volume.

[b] The methanol extract is from the sample previously extracted with acetone.

[c] Roman numerals = unknown compounds; both dichlorobenzophenone and Kelthane cochromatographed at spot I (R_f = .45).

Table 10.-Concentrations of DDT and degradation products in corn grown in a terrestrial model ecosystem.

Compound	R_f[b]	DDT equivalents, ppm, at indicated postplanting age											
		11 Days			12 Days			13 Days			14 Days		
		Root	Shoot	Entire plant	Root	Shoot	Entire plant	Root	Shoot	Entire plant	Root	Shoot	Entire plant
DDE	0.90	0.018	0.950	0.661	0.006	3.644	1.956	0.017	0.387	0.298	0.038	1.255	0.874
DDT	0.80	0.362	52.839	36.625	0.043	63.542	34.077	0.072	10.361	7.881	0.297	13.803	9.573
DDMS	0.70	0.213	2.035	1.458		2.889	1.548		0.368	0.279		0.271	0.186
DDD	0.63	0.020	0.371	0.262	0.083	1.698	0.944	0.064	0.258	0.211	0.170	0.347	0.294
I[a]	0.45				0.003		0.001	0.004		0.001	0.009		0.003
II	0.34				0.008		0.003	0.007		0.002	0.018		0.006
III	0.28	0.053		0.013	0.084		0.034	0.053		0.013			
IV	0.16				0.031		0.013	0.019		0.005			
V	0.10	0.043		0.010	0.004		0.002						
VI	0.05		0.221	0.153		0.462	0.248	0.008	0.025	0.021	0.013		0.004
DDA	0.02	0.029	0.329	0.234	0.013	0.302	0.166	0.025	0.075	0.063	0.003	0.109	0.076
VII	0.0	0.043	1.264	0.884		0.995	0.533		0.284	0.216		0.083	0.057
Extractable ^{14}C		0.781	58.009	40.300	0.275	73.532	39.525	0.269	11.758	8.990	0.548	15.868	11.073
Unextractable ^{14}C		0.014	2.335	1.674	0.009	3.379	1.856	0.017	1.095	0.828	0.023	2.089	1.482
Grand Total ^{14}C		0.795	60.344	41.974	0.284	76.911	41.381	0.286	12.853	9.818	0.571	17.957	12.555
Biosample wgt. (g)		0.40609	1.1498	1.5559	0.74740	1.1599	1.9073	0.53034	1.4701	2.0004	0.79407	1.7336	2.5277

[a] Roman numerals = unknown compounds; both dichlorobenzophenone and Kelthane cochromatographed at Spot I (R_f = 0.45)

[b] Silica Gel GF-254, Hexane: ether, 24:1 by volume.

Table 11.–Concentrations of DDT and degradation products in invertebrates after a 5-day exposure in a terrestrial model ecosystem.

		DDT equivalents, ppm[a]			
Compound	R_f[c]	*Lumbricus* (worm)	*Limax* (slug)	*Armadillidium* (pillbug)	*Estigmene* (caterpillar)
DDE	.90	0.287	0.300	1.455	78.812
DDMU	.84				1.657
DDT	.80	1.180	3.873	3.476	2.984
DDMS	.70	0.184	0.034	0.069	0.659
DDD	.63	0.165	0.766	0.138	0.184
I[b]	.45	0.037	0.034		0.157
II	.42				0.107
III	.33				0.078
IV	.26		0.017		
V	.17		0.010		
VI	.10		0.021		
DDA	.02	0.047	0.043	0.069	0.104
VII	.00	0.076	0.366	0.104	0.363
Extractable ^{14}C		1.976	5.464	5.311	85.105
Unextractable ^{14}C		0.268	0.346	0.218	0.769
Total ^{14}C		2.244	5.810	5.529	85.874
Average biosample wt (g)		3.2106	2.2272	0.0584	0.81801

[a] Average of triplicate determinations.

[b] Roman numerals = unknown compounds; both dichlorobenzophenone and Kelthane cochromatographed at Spot I (R_f = 0.45).

[c] Silica Gel GF-254, Hexane: ether, 24:1 by volume.

Table 12.–Concentrations of DDT and degradation products in the prairie vole[a] from a terrestrial model ecosystem.

Compound	R_f[c]	DDT equivalents, ppm													
		Kidneys + Adrenals	Stomach	Tongue	Heart	Liver	Mammary gland	Large intest.	Carcass	Lung	Brain	Skin	Uterus	Small intest.	Body totals[d]
DDE	.90	19.981	16.841	17.689	14.477	9.942	11.242	5.134	8.626	6.395	7.631	5.631	5.646	4.742	8.201
DDMU	.84		1.223					0.094						0.074	0.050
DDT	.80	2.953	3.875	3.004	2.336	0.477	1.600	0.214	1.521	0.187	1.988	1.554	0.949	0.411	1.373
DDMS	.70		0.204					0.058	0.016					0.033	0.022
DDD	.63	1.055	0.596	0.556	0.565	1.402	0.359	0.408	0.243	0.092	0.146	0.156	0.156	0.587	0.354
I[b]	.45	0.138	0.208	0.182	0.145	0.042	0.143	0.060	0.031	0.093	0.108	0.027	0.062	0.018	0.043
II	.32		0.074		0.038			0.049	0.014			0.011		0.034	0.018
III	.23		0.039	0.037	0.393	0.076	0.031	0.176	0.009				0.013	0.014	0.027
IV	.16	0.017	0.094	0.034	0.064		0.018	0.217	0.016	0.027	0.042	0.045	0.021	0.008	0.035
V	.11							0.084		0.015		0.034			0.010
VI	.09		0.090					0.104		0.040		0.019		0.076	0.019
VII	.07			0.101				0.145	0.028						0.027
VIII	.05		0.082		0.057	0.084	0.131	0.073	0.016	0.160			0.070	0.029	0.027
DDA	.02	0.329	0.321	0.293	0.191	0.098	0.169	0.183	0.106	0.154	0.254	0.153	0.132	0.066	0.127
IX	.00	0.566	0.678	0.505	0.584	0.377	0.237	1.567	0.054	0.363	0.238	0.267	0.277	0.313	0.264
Extractable ^{14}C		25.039	24.325	22.401	18.850	12.498	13.930	8.566	10.680	7.526	10.407	7.897	7.326	6.405	10.597
Unextractable ^{14}C		3.216	0.682	0.747	0.694	2.265	0.669	4.579	0.700	3.733	0.121	1.419	1.567	1.495	1.255
Grand Total ^{14}C		28.255	25.007	23.148	19.544	14.763	14.599	13.145	11.380	11.259	10.528	9.316	8.893	7.900	11.852
Biosample w t (g)		0.35384	0.77300	0.08520	0.17152	1.31106	0.11275	1.86058	15.05200	0.24945	0.53580	2.63529	0.11895	2.05795	

[a] The vole died after being in the ecosystem for 3 days.

[b] Roman numerals = unknown compounds; both dichlorobenzophenone and Kelthane cochromatographed at spot I (R_f = 0.45).

[c] Silica Gel GF-254, Hexane: Diethyl ether, 24:1 by volume.

[d] Body totals were calculated using live body weight, 25.45289 g.

Table 13.—Relative affinities of 13 body-parts of the prairie vole[a] for $[^{14}C]$DDT plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass[b]	56.77	59.45
Skin	8.14	10.41
Large intestine + contents	8.11	7.35
Liver	6.42	5.18
Stomach + contents	6.41	3.05
Small intestine + contents	5.39	8.13
Kidneys + adrenals	3.31	1.40
Brain	1.87	2.12
Heart	1.11	0.68
Lungs	0.93	0.98
Tongue	0.65	0.34
Mammary glands	0.54	0.45
Uterus	0.35	0.47
	100.00	100.01

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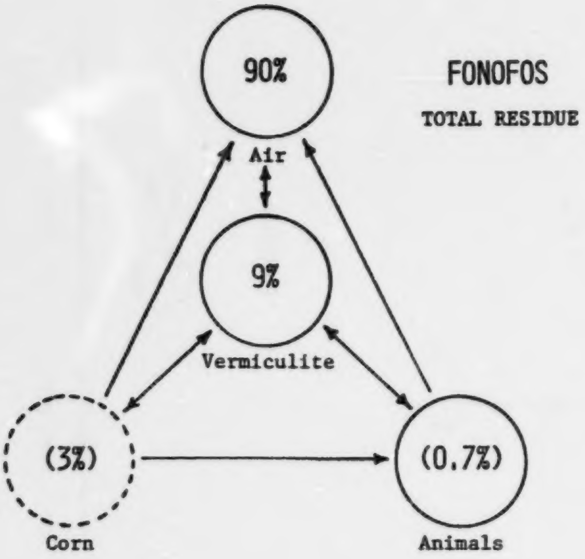
a/ Vole from a vermiculite-terrestrial model ecosystem treated with $[^{14}C]$DDT.

b/ Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.



Calculation of the above estimates:

Ecosystem component	Total maximum mass, g: (No.)	X̄ mass	= total	Mean concentration, µg/g	Total residue, µg: (mass)(conc.)	Total residue as a % of applied dose (5000 µg)
Earthworms[a/]	(10)	3.18	= 31.8		(7)	(0.14)
Slugs	(10)	2.63	= 26.3	0.404	10.6	0.21
Pillbugs[a/]	(20)	0.080	= 1.60		(7)	(0.14)
Pupae	(5)	0.643	= 3.22	1.04	3.35	0.07
Vole	(1)	29.98	= 29.98	0.270	8.09	0.16
Animal total (I)			92.9		(36)	(0.72)
Corn[b/]	(44)	2.95	= 130	1.10	143	2.9
Vermiculite (II)	(1)	2260	= 2260	0.212	479	9.6
Air				[5000 µg-(I+II)] =	4485	89.7

a/ Earthworms and pillbugs were not analyzed in this system. Since the mass of earthworms plus pillbugs was approximately equal to that of slugs plus pupae, it was assumed that their residues were also approximately equal.

b/ Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the system.

Fig. 23.-Terminal environmental distribution of [^{14}C]fonofos plus metabolites in a vermiculite-terrestrial model ecosystem.

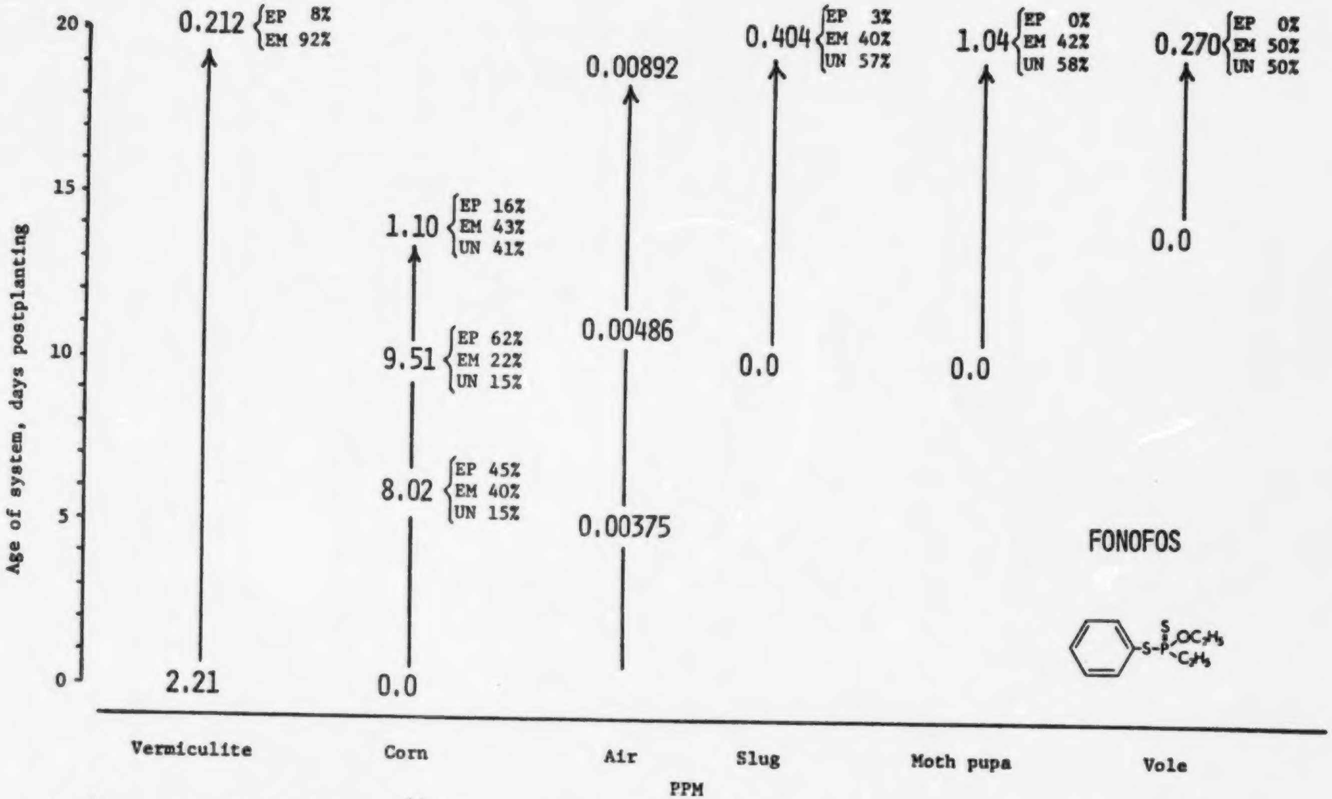


Fig. 24.—Summary of the fate of [^{14}C]fonofos in a vermiculite-terrestrial model ecosystem. The total ^{14}C-residues are expressed as fonofos equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the vermiculite was treated with fonofos at one lb AI/acre. On day 10 the invertebrates were added. On day 14 a male vole was added.

Table 14.—Concentrations of fonofos and degradation products in the vermiculite substrate ("soil") of a terrestrial model ecosystem 20 days after applying the insecticide to the vermiculite.

Compound	R_f[a]	Fonofos equivalents, ppm Acetone extract	Fonofos equivalents, ppm Methanol[b] extract
Fonofos	.80	0.013	0.003
I[c]	.59	0.032	
Dyfoxon	.53	0.005	
II	.36	0.013	
III	.25	0.003	
IV	.19	0.002	
V	.15		0.005
VI	.05	0.005	
VII	.03	0.003	
VIII	.00	0.096	0.032
Total ^{14}C		0.172	0.040
Biosample wt. (g)		100.00	100.00

[a] Silica Gel GF-254, CCl_4: Eth Ac, 1:1 by volume.

[b] The methanol extract is from the sample previously extracted with acetone.

[c] Roman numerals equal unknown compounds.

Table 15.-Concentrations of fonofos and degradation products in the corn from a terrestrial model ecosystem.

		Fonofos equivalents, ppm, at indicated postplanting age								
		6 Days			10 Days			14 Days		
Compound	R_f[a]	Root	Shoot	Entire plant	Root	Shoot	Entire plant	Root	Shoot	Entire plant
Fonofos	.69	4.040	0.791	3.600	10.485	0.219	5.910	0.302	0.042	0.175
I[b]	.29		0.064	0.012		0.037	0.016		0.053	0.025
II	.22		0.067	0.012		0.090	0.040		0.015	0.007
III	.20				0.035		0.019	0.009		0.004
IV	.19		0.288	0.052		0.072	0.032		0.016	0.008
V	.14				0.059		0.033			
VI	.13		0.081	0.015		0.056	0.025		0.020	0.010
VII	.09	0.404		0.346	0.666		0.369	0.048		0.025
VIII	.06	0.869		0.744	0.886		0.491			
IX	.05		0.032	0.006		0.150	0.067		0.040	0.019
X	.04				0.060		0.033	0.020		0.010
XI	.02				0.101		0.056			
XII	.00	2.130	1.052	2.013	1.448	0.291	0.932	0.525	0.196	0.363
Extractable ^{14}C		7.443	2.375	6.800	13.740	0.915	8.023	0.904	0.382	0.646
Unextractable ^{14}C		1.202	1.266	1.224	1.782	1.142	1.484	0.434	0.502	0.457
Total ^{14}C		8.645	3.641	8.024	15.522	2.057	9.507	1.338	0.884	1.103
Biosample wt. (g)		0.9145	0.2585	1.1730	1.1640	0.8970	2.0610	1.3520	1.2365	2.5885

[a] Silica Gel GF-254, chloroform: hexane, 20:80 by volume.

[b] Roman numerals = unknown compounds.

Table 16.-Concentrations of fonofos and degradation products in invertebrates after a 10-20-day exposure in a terrestrial model ecosystem.

Compound	R_f[a]	Fonofos equivalents, ppm *Limax*[b] (slug)	 *Estigmene*[c] (moth pupa)
Fonofos	.80	0.012	
Dyfoxon	.53	0.025	
I	.36	0.072	0.365
II	.25	0.017	
III	.15	0.007	
IV	.05	0.017	
V	.00	0.022	0.069
Extractable ^{14}C		0.172	0.434
Unextractable ^{14}C		0.232	0.609
Total ^{14}C		0.404	1.043
Biosample wt. (g)		1.7724	0.64345

[a] Silica Gel GF-254, CCl_4: Eth Ac, 1:1 by volume.

[b] Average of six determinations.

[c] Average of two determinations.

Table 17.-Concentrations of fonofos and degradation products in the prairie vole after a 5-day exposure in a terrestrial model ecosystem.

		Fonofos equivalents, ppm											
Compound	R_f a/	Large intestine	Stomach b/	Carcass	Kidneys + adrenals	Heart	Tongue	Small intestine	Liver	Seminal vesicles	Fat	Brain	Body c/ totals
Fonofos	.80												
I	.62			0.057									0.041
Dyfoxon	.53	0.020		0.090									0.066
II	.48	0.053						0.015					0.003
III	.42	0.043											0.002
IV	.20			0.001									<0.001
V	.02			0.002									0.001
VI	.00	0.162		0.006				0.020					0.011
Extractable ^{14}C		0.278	0.251	0.156	0.034	0.033	0.022	0.035	0.011	0.023	0.016	0.006	0.136
Unextractable ^{14}C		0.518	0.191	0.132	0.123	0.120	0.088	0.054	0.059	0.030	0.008	0.011	0.134
Total ^{14}C		0.796	0.442	0.288	0.157	0.153	0.110	0.089	0.070	0.053	0.024	0.017	0.270
Biosample wt	(g)	1.1907	1.1997	21.600	0.5021	0.2168	0.1696	1.2374	1.6453	0.8771	0.4098	0.5787	

a/ Silica Gel GF-254, CCl_4: Eth Ac, 1:1 by volume.

b/ The concentrations of individual degradation products in the following organs were of insufficient magnitude to be quantitated: stomach, kidneys plus adrenals, heart, tongue, liver, seminal vesicles, fat, brain.

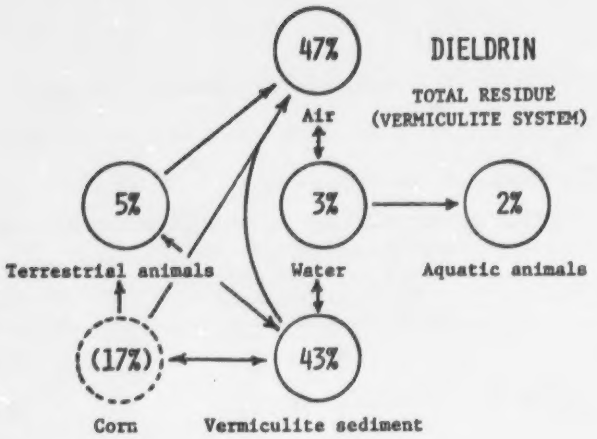
c/ The body totals were calculated using live wet weight (29.984 g).

Table 18.—Relative affinities of 11 body-parts of the prairie vole[a] for $[^{14}C]$fonofos (Dyfonate®) plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass (including skin)[b]	76.53	72.91
Large intestine + contents	11.72	4.02
Stomach + contents	6.55	4.05
Liver	1.42	5.55
Small intestine	1.36	4.18
Kidneys + adrenals	0.98	1.69
Seminal vesicles	0.57	2.96
Heart	0.41	0.73
Tongue	0.23	0.57
Brain	0.11	1.95
Abdominal fat	0.11	1.38
	99.99	99.99

[a] Vole from a vermiculite-terrestrial model ecosystem treated with $[^{14}C]$fonofos.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle, skin and bone.



Calculation of the above estimates:

Ecosystem component	Total maximum mass, g: (No.)	$\overline{X}$ mass	= total	Mean concentration, µg/g	Total residue, µg: (mass)(conc.)	Total residue as a % of applied dose (5000 µg)
Earthworms	(8)	3.48	= 27.8	3.62	101	2.0
Slugs	(8)	4.55	= 36.4	0.771	28.1	0.6
Pillbugs	(13)	0.0768	= 0.998	8.87	8.85	0.2
Caterpillars	(8)	0.668	= 5.34	1.34	7.16	0.1
Vole	(1)	22.81	= 22.81	3.67	83.8	1.7
Terrestrial animal[a] total (I)			93.3		229	4.6
Corn[b]	(44)	3.41	= 150	5.66	849	17.0
Daphnia	(600)	0.00344	= 2.06	8.81	18.1	0.5
Snails	(50)	0.017	= 0.850	70.3	59.8	1.2
Fish	(3)	0.160	= 0.480	62.6	30.0	0.6
Aquatic animal total (II)			3.38		108	2.3
Surface water (III)	(1)	7000	= 7000	0.022	154	3.1
Vermic. sediment[c] (IV)	(1)	2400	= 2400	0.894	2146	42.9
Air			[5000 µg-(I+II+III+IV)]		= 2363	47.3

[a] The terrestrial animals (and their residues) were removed from the system at the termination of the terrestrial phase.

[b] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the terrestrial phase, and its residue is distributed among animals, air, and vermiculite.

[c] The direct interaction of corn, air, and terrestrial animals with the vermiculite occurred prior to flooding the system.

Fig. 25.-Terminal environmental distribution of [^{14}C]dieldrin plus metabolites in a vermiculite-terrestrial model ecosystem.

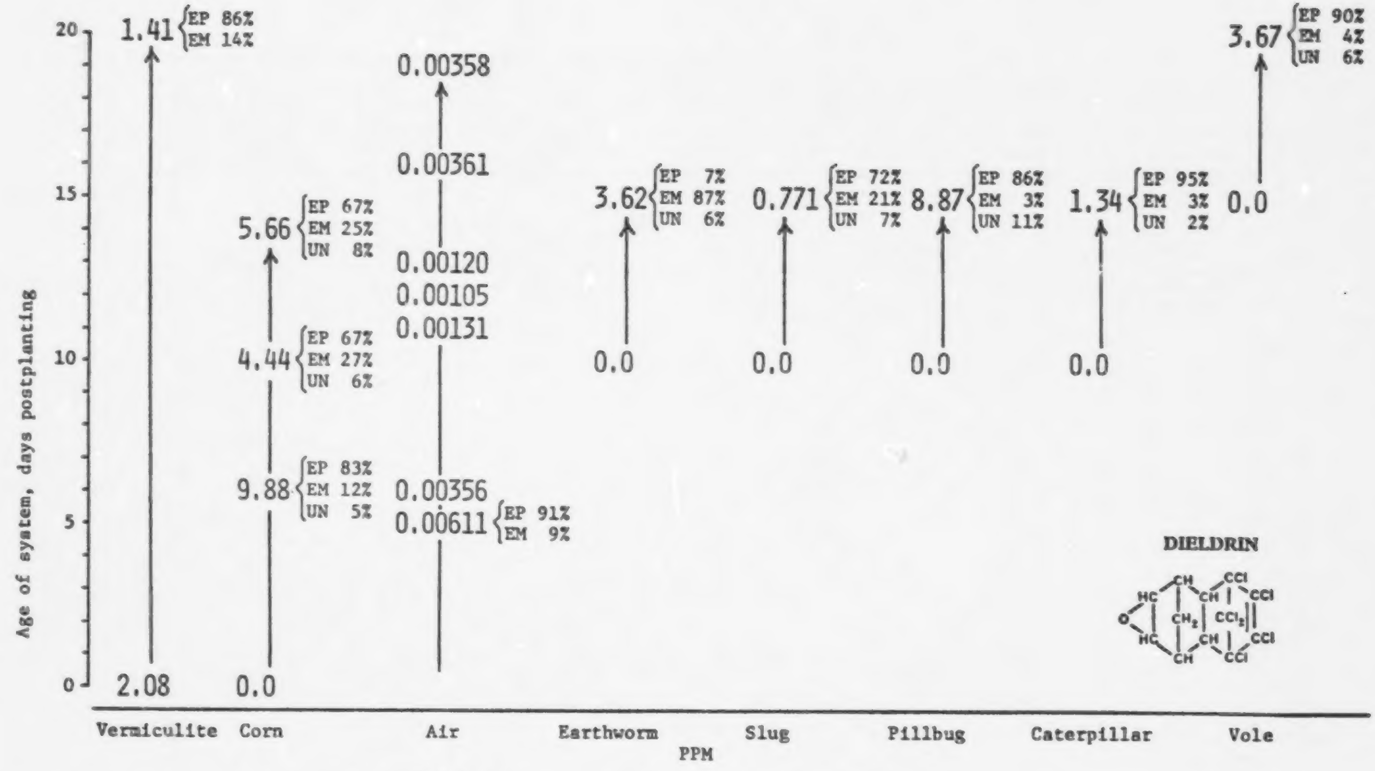


Fig. 26.—Summary of the fate of $[^{14}C]$dieldrin in the terrestrial phase of a vermiculite-terrestrial model ecosystem. The total ^{14}C-residues are expressed as dieldrin equivalents, ppm (w/w), and their subdivisions are: EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the vermiculite was treated with dieldrin at one lb AI/acre. The invertebrates and vole were added to the system 10 and 15 days later, respectively.

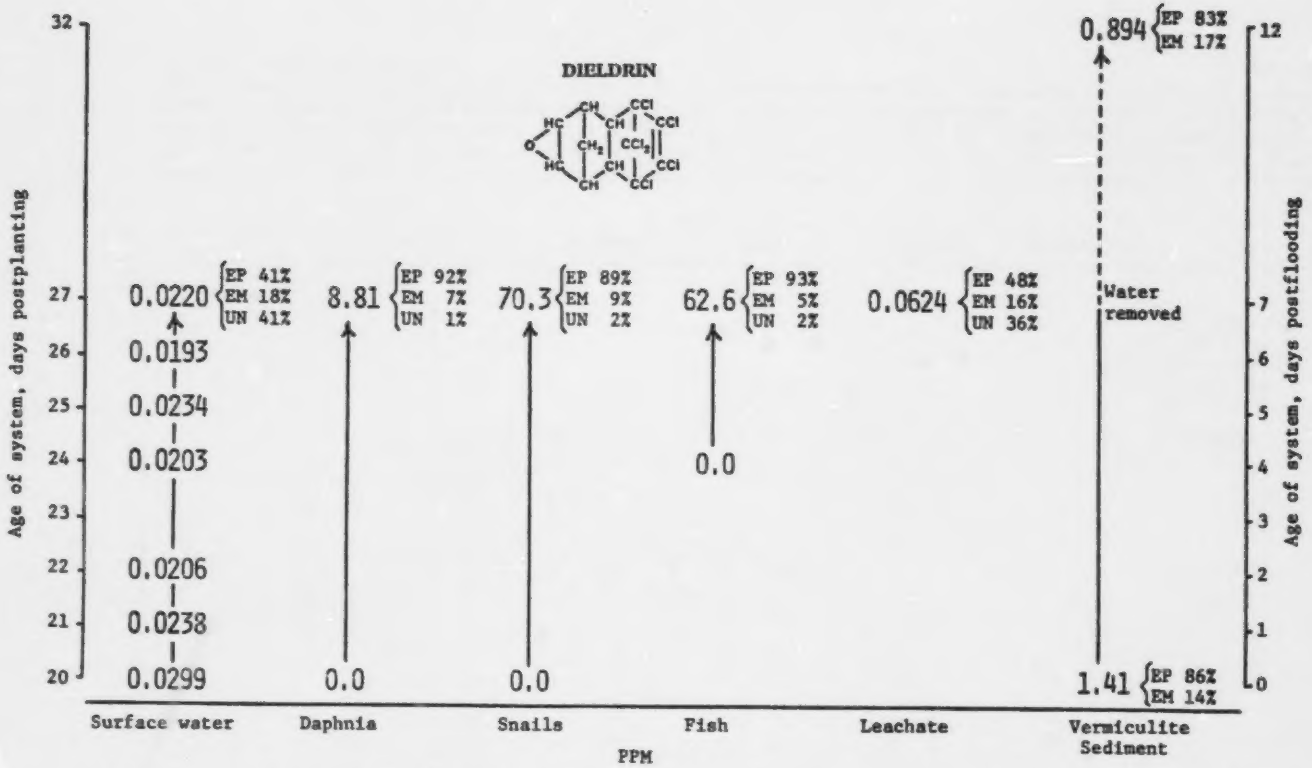


Fig. 27.—Summary of the fate of [^{14}C]dieldrin in the aquatic phase; an extension of a vermiculite-terrestrial model ecosystem (see Fig. 26). The barren terrestrial phase was flooded 20 days postplanting and snails, Daphnia, and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as dieldrin equivalents, ppm (w/w), and their subdivisions are: EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 19.-Concentrations of [^{14}C]dieldrin and degradation products in the vermiculite of a model ecosystem 20 days after application of [^{14}C]dieldrin to the vermiculite

Compound	Rf[a]	Dieldrin equivalents, ppm	
		Acetone extract	Methanol extract[b]
I[c]	.93	0.0085	0.0005
II	.90	0.0412	0.0038
Dieldrin	.85	1.1441	0.0686
III	.79	0.0067	0.0004
IV	.69	0.0034	
V	.66	0.0274	0.0017
VI	.49	0.0020	0.0001
VII	.41	0.0046	0.0002
VIII	.34	0.0526	0.0031
IX	.25	0.0072	0.0004
X	.17	0.0028	0.0002
XI	.06		0.0002
XII	.03	0.0082	0.0002
XIII	.00	0.0228	0.0004
Extractable ^{14}C		1.3315	0.0798
Sample wt (g)		100.000	100.000

[a] Silica gel GF-254, _n_-hexane : diethyl ether, 3:2 by volume.

[b] Methanol extract is from the sample previously extracted with acetone.

[c] Roman numerals = unknown compounds.

Table 20.-Concentrations of [^{14}C]dieldrin and degradation products in corn[a] grown in a vermiculite model ecosystem

		Dieldrin equivalents, ppm[b]								
		6 days			10 days			14 days		
Compound	Rf[c]	Root	Shoot	Entire plant	Root	Shoot	Entire plant	Root	Shoot	Entire plant
I[d]	.92				0.355		0.189	0.265		0.138
Dieldrin	.90	11.515	0.968	8.209	5.449	0.015	2.984	6.779	0.011	3.797
II	.88	0.115		0.079						
III	.50-.69[e]					0.047	0.021		0.074	0.032
IV	.69				0.071	0.021	0.047	0.043		0.023
V	.56								0.138	0.061
VI	.47	0.115	0.011	0.082					0.157	0.069
VII	.28-.44					0.282	0.124			
VIII	.04-.38					0.149	0.066		0.031	0.013
IX	.36				0.186		0.099	0.141		0.073
X	.13								0.132	0.058
XI	.07					0.028	0.013			
XII	.05		0.011	0.003						
XIII	.00	1.511	0.019	1.047	1.090	0.047	0.645	1.553	0.134	0.969
Extractable ^{14}C		13.256	1.009	9.420	7.151	0.589	4.188	8.781	0.677	5.233
Unextractable ^{14}C		0.659	0.025	0.460	0.435	0.037	0.255	0.716	0.080	0.431
Total ^{14}C		13.915	1.034	9.880	7.586	0.626	4.443	9.497	0.757	5.664
Avg biosample wt (g)		0.733	0.335	1.068	0.895	0.694	1.589	0.999	0.795	1.794

[a] [^{14}C]Dieldrin was applied to the vermiculite beneath each seed; plants were harvested at indicated post-planting ages.

[b] Average of duplicate determinations.

[c] Silica gel GF-254, *n*-hexane : diethyl ether, 3:2 by volume.

[d] Roman numerals = unknown compounds.

[e] Rf range denotes streak on TLC plate.

Table 21.-Concentrations of [^{14}C]dieldrin and degradation products in the air[a]
from a vermiculite model ecosystem

		Dieldrin equivalents, ppm	
Compound	Rf[b]	Trap 1[c]	Trap 2[d]
I[e]	.92	0.00002	
II	.89	0.00039	
Dieldrin	.86	0.00513	
III	.67	0.00003	
IV	.00	0.00004	
Total ^{14}C		0.00561	0.00050
Sum ^{14}C, Traps 1 & 2		0.00611	
Air sample wt (g)[f]		108.0	

a/ Air was trapped for a 3-hour daylight period at a flow rate of 10 ml/sec 5 days after application of [^{14}C]dieldrin to the vermiculite.

b/ Silica gel GF-254, *n*-hexane : diethyl ether, 3:2 by volume.

c/ Trap 1 was connected directly to the ecosystem container and contained 75 ml of acetonitrile as the trapping solvent; the trapping solvent was chromatographed.

d/ Trap 2 was connected in series to trap 1 and contained 75 ml of trapping solvent (ethanolamine : 2-methoxyethanol, 1:2 by volume); the trap 2 solvent was not chromatographed.

e/ Roman numerals = unknown compounds.

f/ One liter of air was assumed to weigh 1 g.

Table 22.—Concentrations of $[^{14}C]$dieldrin and degradation products in invertebrates after a 5-day exposure in a vermiculite model ecosystem.

		Dieldrin equivalents, ppm[a]			
Compound	R_f[b]	*Armadillidium* (pillbug)	*Estigmene* (caterpillar)	*Limax* (slug)	*Lumbricus* (worm)
Dieldrin	.80	7.594	1.263	0.554	0.255
I[c]	.71				3.062
II	.59			0.057	0.028
III	.31	0.014	0.032	0.033	0.037
IV	.24	0.208	0.006	0.023	0.008
V	.20			0.009	
VI	.03	0.028		0.022	0.018
VII	.00	0.041	0.005	0.017	0.010
Extractable ^{14}C		7.885	1.306	0.715	3.418
Unextractable ^{14}C		0.986	0.030	0.056	0.202
Total ^{14}C		8.871	1.336	0.771	3.620
Average biosample wt. (g)		0.077	0.668	4.554	3.475

[a] Average of triplicate determinations.

[b] Silica gel GF-254, n-hexane : diethyl ether, 3:2 by volume.

[c] Roman numerals = unknown compounds.

Table 23.-Concentrations of [^{14}C]dieldrin and degradation products in the prairie vole after a 5-day exposure in a vermiculite model ecosystem.

Compound	R$_f$[a]	Dieldrin equivalents, ppm													
		Pectoral fat	Mammary glands	Uterus	Skin	Kidneys and adrenals	Stomach	Carcass	Liver	Tongue	Heart	Intestine	Lungs	Brain	Body totals
I[b]	.88						0.132					0.032			0.012
Dieldrin	.81	42.875	40.614	22.941	5.326	4.304	3.205	3.472	2.434	2.282	2.241	0.915	0.790	0.573	3.285
II	.45						0.020								0.001
III	.30	0.260	0.225	0.160	0.035	0.032	0.099	0.036	0.025		0.027	0.034			0.033
IV	.25													0.006	<0.001
V	.20	0.159	0.137	0.080	0.024	0.020	0.045	0.010	0.019						0.013
VI	.12						0.019		0.024						0.002
VII	.05						0.044					0.129			0.021
VIII	.03						0.102		0.113						0.015
IX	.00	0.037		0.025	0.016	0.098	0.147	0.027	0.130	0.016	0.014	0.154	0.022	0.002	0.055
Extractable ^{14}C		43.331	40.976	23.206	5.401	4.454	3.813	3.545	2.745	2.298	2.282	1.264	0.812	0.581	3.437
Unextractable ^{14}C		0.004	0.051	0.064	1.080	0.078	0.214	0.101	0.134	0.050	0.043	0.351	0.049	0.013	0.235
Total ^{14}C		43.335	41.027	23.270	6.481	4.532	4.027	3.646	2.879	2.348	2.325	1.615	0.861	0.594	3.672
Biosample wt (g)		0.095	0.079	0.065	2.325	0.373	1.281	11.785	1.213	0.095	0.223	3.259	0.188	0.580	22.810[c]

[a] Silica gel GF-254 n-hexane : diethyl ether, 3:2 by volume.

[b] Roman numerals = unknown compounds.

[c] Live body weight.

Table 24.—Relative affinities of 13 body-parts of the prairie vole[a/] for [^{14}C]dieldrin plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass	51.30	54.66
Skin	17.99	10.78
Intestines + contents	6.28	15.12
Stomach + contents	6.16	5.94
Pectoral fat	4.90	0.44
Liver	4.17	5.63
Mammary glands	3.88	0.37
Kidneys + adrenals	2.02	1.73
Uterus	1.81	0.30
Heart	0.62	1.03
Brain	0.41	2.69
Tongue	0.27	0.44
Lungs	0.19	0.87
	100.00	100.00

[a/] Vole from a vermiculite-terrestrial model ecosystem treated with [^{14}C]dieldrin.

[b/] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

Table 25.-Concentrations of $[^{14}C]$dieldrin and degradation products in the water of a vermiculite model ecosystem 7 days after flooding the ecosystem with water[a/]

Compound	Rf[c/]	Dieldrin equivalents, ppm			
		Surface water		Leachate[b/]	
		Ether-extractable before hydrolysis	Ether-extractable after hydrolysis[d/]	Ether-extractable before hydrolysis	Ether-extractable after hydrolysis
I[e/]	.93			0.00053	
Dieldrin	.88	0.00899	0.00018	0.03013	0.00126
II	.80	0.00019		0.00043	0.00008
III	.76			0.00007	
IV	.72	0.00017	0.00002	0.00025	
V	.65			0.00054	
VI	.56	0.00010		0.00017	
VII	.53	0.00009		0.00029	
VIII	.49	0.00045		0.00124	
IX	.46	0.00097		0.00167	
X	.39	0.00115	0.00002	0.00174	0.00004
XI	.34				0.00007
XII	.30		0.00009		0.00008
XIII	.20				0.00010
XIV	.17	0.00017		0.00053	0.00045
XV	.12		0.00007		0.00083
XVI	.09		0.00019		
XVII	.05	0.00008	0.00038		0.00175
XVIII	.03	0.00007	0.00171	0.00072	0.00217
XIX	.00	0.00063	0.00040	0.00165	0.00047
Extractable ^{14}C		0.01306	0.00306	0.03996	0.00730
Unextractable ^{14}C			0.00209		0.00436
Total extractable ^{14}C		0.01612		0.04726	
Unextractable ^{14}C after hydrolysis		0.00209		0.00436	
^{14}C loss during hydrolysis		0.00380		0.01080	
Initial ^{14}C in water		0.02201		0.06242	
Sample volume (1)		1.000		1.000	

a/ Ecosystem was flooded with water 20 days after application of $[^{14}C]$dieldrin to the vermiculite.
b/ One liter of water was withdrawn through the tap at the jar bottom over a period of 25 min.
c/ Silica gel GF-254, n-hexane : diethyl ether, 3:2 by volume.
d/ The "unextractable" of the preceding column was adjusted to 0.012 N HCl and maintained at 55-56°C for 18-24 hr.
e/ Roman numerals = unknown compounds.

Table 26.-Concentrations of [^{14}C]dieldrin and degradation products in aquatic organisms of a vermiculite model ecosystem flooded with water[a]

		Dieldrin equivalents, ppm[b]		
Compound	Rf[c]	Gambusia[d] (fish)	Physa[e] (snail)	Daphnia[f] (water flea)
I[g]	.92	0.101	0.267	
II	.89	1.612	2.270	0.228
Dieldrin	.83	58.066	62.942	8.048
III	.66	0.276	0.626	0.113
IV	.38		0.224	
V	.31	1.190	2.063	0.279
VI	.26	0.143	0.418	0.017
VII	.03		0.095	
VIII	.00	0.147	0.073	0.014
Extractable ^{14}C		61.535	68.978	8.699
Unextractable ^{14}C		1.055	1.368[h]	0.106
Total ^{14}C		62.590	70.346	8.805
Average biosample wt (g)		0.160	0.017	1.032

[a] Ecosystem was flooded with water 20 days after application of [^{14}C]dieldrin to the vermiculite.

[b] Average of triplicate determinations for fish; average of duplicate determinations for snails; single determination for water fleas.

[c] Silica gel GF-254, n-hexane : diethyl ether, 3:2 by volume.

[d] Fish were added 4 days after flooding the ecosystem, removed 3 days later, and processed individually.

[e] Snails were added on the day of flooding, removed 7 days later, and processed in 2 batches of 15 snails each; average batch weight = 0.252 g.

[f] Daphnia were added on the day of flooding, removed 7 days later, and processed as a batch; many organisms constituted the biosample.

[g] Roman numerals = unknown compounds.

[h] Part of concentrated extract was added to residue pellet during processing.

Table 27.-Concentrations of $[^{14}C]$dieldrin and degradation products in the vermiculite sediment of a model ecosystem 12 days after flooding the ecosystem with water[a]

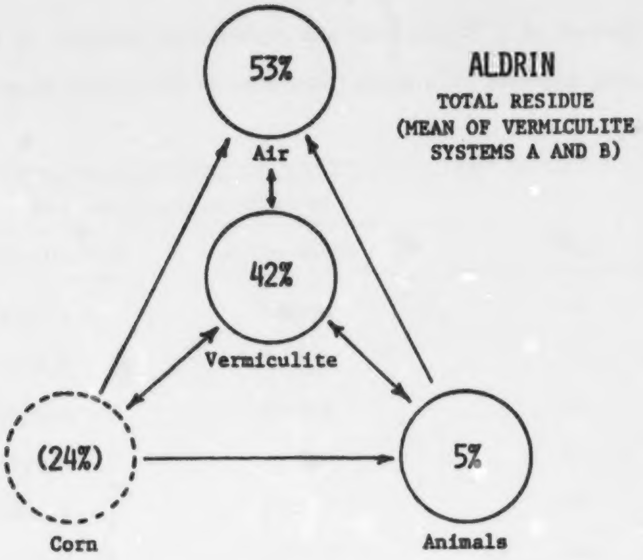
Compound	Rf[b]	Dieldrin equivalents, ppm	
		Acetone extract	Methanol extract[c]
I[d]	.93	0.0055	0.0006
II	.90	0.0503	0.0073
Dieldrin	.85	0.6925	0.0520
III	.79	0.0039	0.0006
IV	.66	0.0154	0.0013
V	.49	0.0071	0.0004
VI	.45	0.0028	0.0001
VII	.41	0.0026	0.0002
VIII	.34	0.0216	0.0010
IX	.31	0.0034	0.0001
X	.25	0.0069	0.0004
XI	.22	0.0013	
XII	.17	0.0043	0.0002
XIII	.03	0.0044	0.0002
XIV	.00	0.0070	0.0004
Extractable ^{14}C		0.8290	0.0648
Sample wt (g)		100.000	100.000

[a] Ecosystem was flooded with water 20 days after application of $[^{14}C]$dieldrin to the vermiculite.

[b] Silica gel GF-254, n-hexane : diethyl ether, 3:2 by volume.

[c] Methanol extract is from the sample previously extracted with acetone.

[d] Roman numerals = unknown compounds.


53%
Air
ALDRIN
TOTAL RESIDUE
(MEAN OF VERMICULITE SYSTEMS A AND B)
42%
Vermiculite
(24%)
Corn
5%
Animals

Calculation of the above estimates:

Ecosystem component	Total maximum mass, g: (No.)	$\overline{X}$ mass	= total	Mean concentration, µg/g	Total residue, µg: (mass)(conc.)	Total residue as a % of applied dose (5000 µg)
Earthworms	(8)	3.98	= 31.8	4.13	131	2.6
Slugs	(8)	2.52	= 20.2	2.58	52.1	1.0
Pillbugs	(13)	0.0335	= 0.436	3.22	1.40	<0.1
Caterpillars	(8)	0.744	= 5.95	3.38	20.1	0.4
Vole	(1)	34.0	= 34.0	1.31	44.5	0.9
Animal total (I)			92.4		249	4.9
Corn[a/]	(44)	3.41	= 150	8.05	1208	24.2
Vermiculite (II)	(1)	2400	= 2400	0.882	2117	42.3
Air				[5000 µg-(I+II)]	= 2634	52.6

[a/] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the system.

Fig. 28.-Mean terminal environmental distribution of [^{14}C]aldrin plus metabolites in vermiculite-terrestrial model ecosystems A and B.

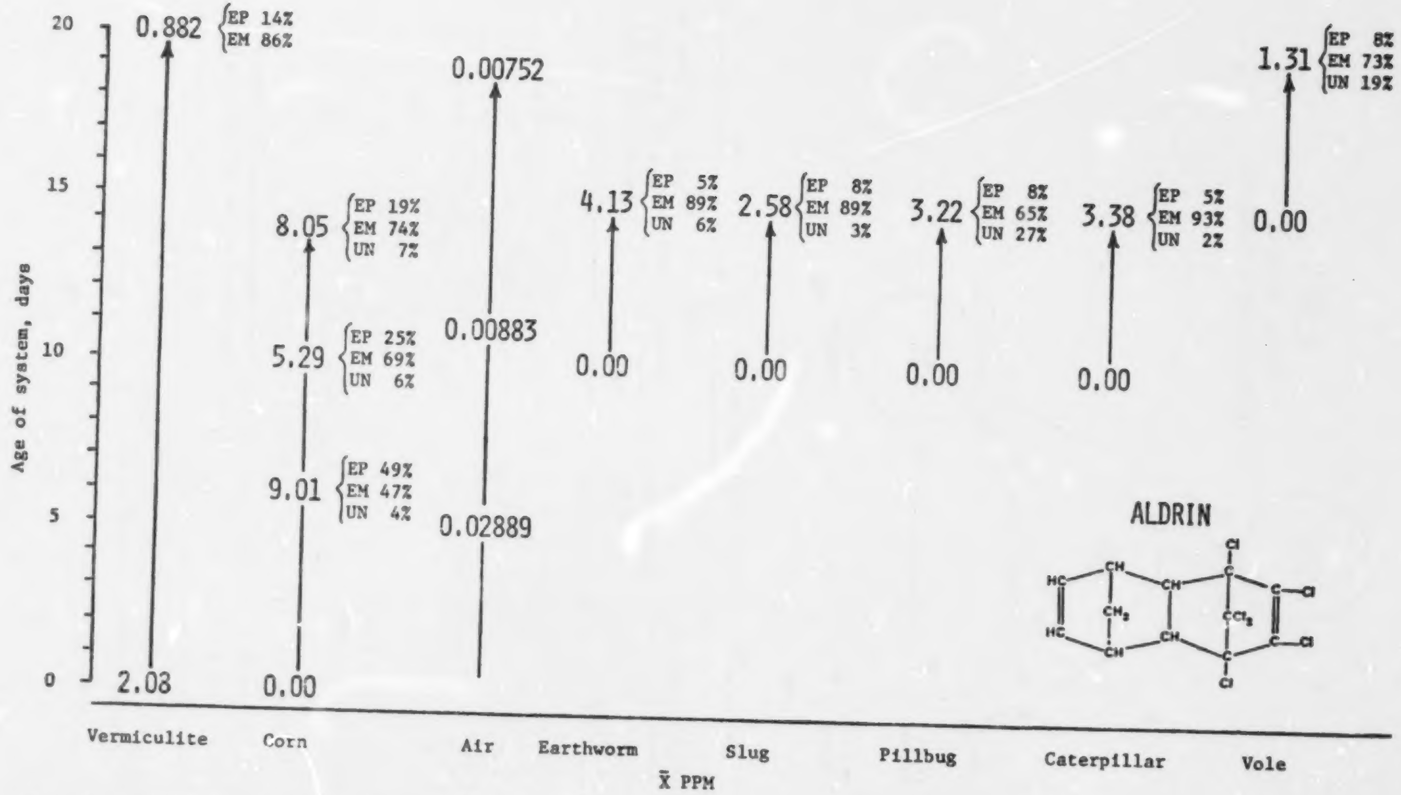
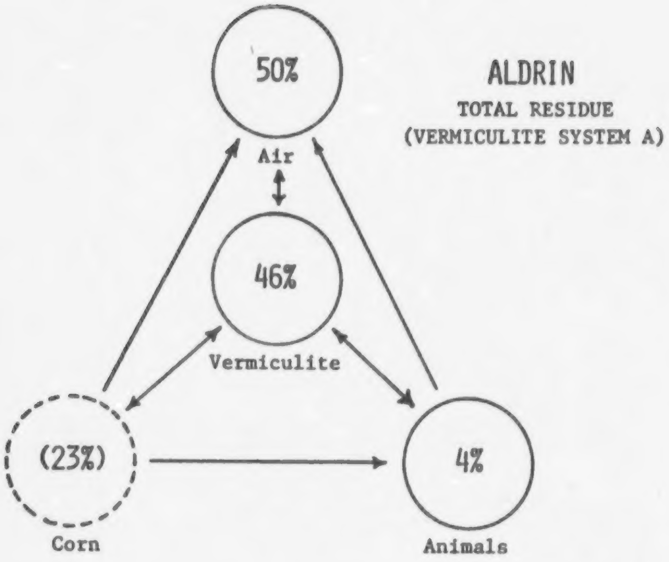


Fig. 29.—Mean summary of the fate of [^{14}C]aldrin in vermiculite-terrestrial model ecosystems A and B. The total ^{14}C-residues are expressed as aldrin equivalents, ppm (w/w), and their subdivisions are: EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the vermiculite was treated with aldrin at one lb AI/acre; the invertebrates and vole were added to the system 10 and 15 days later, respectively.


50%
Air
46%
Vermiculite
(23%)
Corn
4%
Animals
ALDRIN
TOTAL RESIDUE
(VERMICULITE SYSTEM A)

Calculation of the above estimates:

Ecosystem component	Total maximum mass, g: (No.)	$\overline{X}$ mass	= total	Mean concentration, µg/g	Total residue, µg: (mass)(conc.)	Total residue as a % of applied dose (5000 µg)
Earthworms	(8)	3.98	= 31.8	31.2	99.2	2.0
Slugs	(8)	2.52	= 20.2	2.06	41.6	0.8
Pillbugs	(13)	0.0335	= 0.436	3.62	1.58	<0.1
Caterpillars	(8)	0.744	= 5.95	4.32	25.7	0.5
Vole	(1)	26.1	= 26.1	2.14	55.9	1.1
Animal total (I)			84.5		224	4.4
Corn[a/]	(44)	3.41	= 150	7.77	1166	23.3
Vermiculite (II)	(1)	2400	= 2400	0.954	2290	45.8
Air				[5000 µg-(I+II)]	= 2486	49.7

[a/] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the system.

Fig. 30.-Terminal environmental distribution of $[^{14}C]$aldrin plus metabolites in vermiculite-terrestrial model ecosystem A.

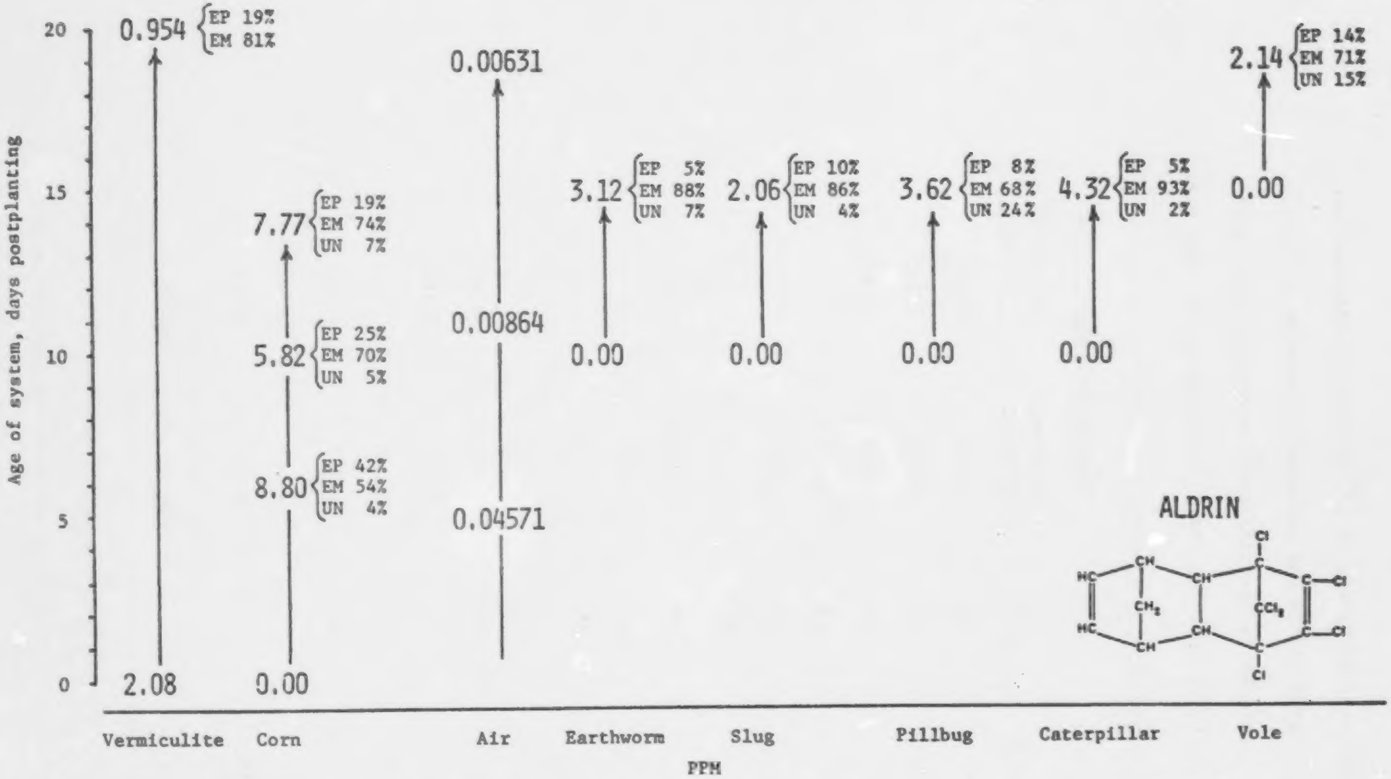


Fig. 31.—Summary of the fate of [^{14}C]aldrin in the vermiculite-terrestrial model ecosystem A. The total ^{14}C-residues are expressed as aldrin equivalents, ppm (w/w), and their subdivisions are: EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the vermiculite was treated with aldrin at one lb AI/acre; the invertebrates and vole were added to the system 10 and 15 days later, respectively. The vole died 3-3/4 days after placing it in the system.

Table 28.-Concentrations of $[^{14}C]$ Aldrin and degradation products in the vermiculite substrate ("soil") of the terrestrial model ecosystem A, 20 days after applying the $[^{14}C]$Aldrin to the substrate.

Compounds	R_f[a]	Aldrin equivalents, ppm Acetone extract	 Methanol[b] extract
Aldrin	.97	0.175	0.011
Dieldrin	.90	0.459	0.015
I[c]	.82	0.047	0.002
II	.73	0.011	
III	.69	0.003	
IV	.56	0.003	
V	.46	0.024	0.001
VI	.39	0.005	
VII	.35		
VIII	.31		
IX	.27	0.018	0.001
X	.17	0.009	0.001
XI	.09	0.008	
XII	.04	0.021	0.002
XIII	.00	0.125	0.013
Total ^{14}C		0.908	0.046
Sample wt. (g)		100.00	100.00

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[a] Silica Gel GF-254, n-hexane : diethyl ether, 3 : 2 by volume.

[b] The methanol extract is from the sample previously extracted with acetone.

[c] Roman numerals = unknown compounds.

Table 29.—Concentrations of [^{14}C]Aldrin and degradation products in corn grown in the vermiculite-terrestrial model ecosystem A.

Compound	R_f a/	Aldrin equivalents, ppm, at indicated postplanting age								
		6 Days			10 Days			14 Days		
		Root	Shoot	Entire plant	Root	Shoot	Entire plant	Root	Shoot	Entire plant
Aldrin	.97	4.473	0.848	3.683	3.221	0.069	1.460	3.058	0.081	1.486
Dieldrin	.87	3.891	0.664	3.188	6.019	0.068	2.693	7.396	0.080	3.533
I b/	.74	0.306	0.665	0.384	0.475	0.154	0.296	1.206	0.181	0.664
II	.58					0.317	0.178		0.372	0.196
III	.48					0.290	0.162		0.340	0.179
IV	.42	0.125		0.098	0.399		0.176	0.660		0.311
V	.38					0.113	0.063		0.133	0.070
VI	.18					0.020	0.011		0.024	0.012
VII	.11	0.265		0.207	0.086		0.038	0.107		0.050
VIII	.06	0.086	0.126	0.095	0.049		0.022	0.061		0.029
IX	.04	0.358	0.094	0.300	0.205		0.090	0.300		0.142
X	.00	0.593	0.224	0.512	0.573	0.208	0.369	0.987	0.244	0.594
Extractable ^{14}C		10.097	2.621	8.467	11.027	1.239	5.558	13.775	1.455	7.266
Unextractable ^{14}C		0.406	0.051	0.329	0.513	0.061	0.262	0.977	0.087	0.504
Total ^{14}C		10.503	2.672	8.796	11.540	1.300	5.820	14.752	1.542	7.770
Biosample wt. (g)		1.225	0.340	1.565	0.748	0.852	1.600	0.785	0.860	1.645

a/ Silica Gel GF-254, n-hexane: diethyl ether, 60:40 by volume.

b/ Roman numerals = unknown compounds.

Table 30.-Concentrations of $[^{14}\mathrm{C}]$aldrin and degradation products in invertebrates after a 5-day exposure in the vermiculite-terrestrial model ecosystem A

Compound	Rf[b]	Aldrin equivalents, ppm[a]			
		Lumbricus (worm)	*Limax* (slug)	*Armadillidium* (pillbug)	*Estigmene* (caterpillar)
Aldrin	.98	0.165	0.207	0.290	0.220
Dieldrin	.90	0.235	1.640	2.029	3.627
I[c]	.80	2.345	0.068		0.327
II	.73		0.007	0.065	
III	.41		0.009	0.137	
IV	.36	0.053		0.167	0.051
V	.27		0.018	0.026	
VI	.08	0.015			
VII	.04	0.045	0.010		
VIII	.00	0.040	0.022	0.030	0.034
Extractable $^{14}\mathrm{C}$		2.898	1.981	2.744	4.259
Unextractable $^{14}\mathrm{C}$		0.226	0.075	0.878	0.064
Total $^{14}\mathrm{C}$		3.124	2.056	3.622	4.323
Average bio-sample wt (g)		4.51656	1.35427	0.02628	0.84410

[a] Average of triplicate determinations for pillbugs and caterpillars; average of duplicate determinations for slugs; single determination for worm.

[b] Silica gel GF-254, *n*-hexane : diethyl ether, 3:2 by volume.

[c] Roman numerals = unknown compounds.

Table 31.—Concentrations of [^{14}C]Aldrin and degradation products in the prairie vole after a 5-day exposure in the vermiculite-terrestrial model ecosystem A.

Compound	R_f[a]	Aldrin equivalents, ppm												
		Kidneys and Adrenals	Liver	Uterus	Heart	Brain	Carcass	Intest.	Stomach	Skin	Lungs	Bladder	Parotids	Body Totals
Aldrin	.97		5.577			0.038	0.026	0.033	0.029	0.050		0.011		0.290
Dieldrin	.94	7.405		2.413	2.027	1.742	1.924	1.339	1.193	0.482		0.451		1.445
I[b]	.84	0.009				0.008		0.030	0.026	0.011		0.010		0.007
II	.48		0.027			0.030	0.016	0.011	0.010			0.004		0.011
III	.42	0.027	0.043		0.016			0.008	0.007			0.003		0.004
IV	.34				0.015	0.011	0.009			0.005				0.006
V	.28	0.024								0.002				0.001
VI	.25		0.060	0.003		0.016		0.001	0.001	0.001				0.003
VII	.15		0.011							0.002				0.001
VIII	.10		0.012			0.031		0.005	0.005			0.002		0.002
IX	.05		0.017			0.106	0.013	0.015	0.014	0.002		0.005		0.012
X	.00	0.006	0.101	0.027	0.012	0.043	0.010	0.013	0.011	0.002		0.004		0.013
Extractable ^{14}C		7.471	5.848	2.443	2.070	2.025	1.998	1.455	1.296	0.557	1.233	0.490	0.045	1.821[c]
Unextractable ^{14}C		0.036	0.264	0.073	0.076	0.111	0.106	0.192	0.328	0.818	0.083	0.345	0.003	0.314
Total ^{14}C		7.507	6.112	2.516	2.146	2.136	2.104	1.647	1.624	1.375	1.316	0.835	0.048	2.135
Biosample wt (g)		0.50313	1.21509	0.08726	0.33518	0.52473	12.71500	2.88175	0.48150	6.90475	0.32015	0.09848	0.09918	26.16620

[a] Silica Gel GF-254, n-hexane : diethyl ether, 3:2 by volume.

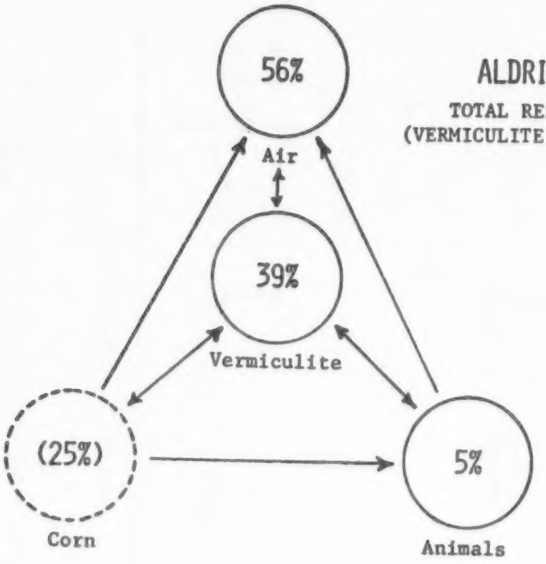
[b] Roman numerals = unknown compounds.

[c] This value represents total extractable ^{14}C in all organs; two organ extracts were not subjected to TLC separation.

Table 32.—Relative affinities of 12 body-parts of the prairie vole for $[^{14}C]$aldrin plus its metabolites, and comparisons with the relative masses of the body-parts; the vole is from vermiculite-terrestrial model ecosystem A.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass[a/]	47.90	48.59
Skin	16.98	26.39
Liver	13.29	4.64
Intestines + contents	8.49	11.01
Kidneys + adrenals	6.76	1.92
Brain	2.01	2.01
Stomach + contents	1.40	1.84
Heart	1.29	1.28
Lungs	0.76	1.22
Parotid glands	0.59	0.38
Uterus + ovaries	0.39	0.33
Bladder + contents	0.15	0.38
	100.01	99.99

a/ Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.



ALDRIN

TOTAL RESIDUE
(VERMICULITE SYSTEM B)

Calculation of the above estimates:

Ecosystem component	Total maximum mass, g: (No.) $\overline{X}$ mass = total	Mean concentration, µg/g	Total residue, µg: (mass)(conc.)	Total residue as a % of applied dose (5000 µg)
Earthworms	(8) 3.98 = 31.8	5.14	164	3.3
Slugs	(8) 2.52 = 20.2	3.10	62.5	1.2
Pillbugs	(13) 0.0335 = 0.436	2.81	1.22	<0.1
Caterpillars	(8) 0.744 = 5.95	2.43	14.5	0.3
Vole	(1) 41.8 = 41.8	0.478	20.0	0.4
Animal total (I)	100		262	5.2
Corn[a/]	(44) 3.41 = 150	8.33	1250	25.0
Vermiculite (II)	(1)2400 = 2400	0.809	1942	38.8
Air		[5000 µg-(I+II)]	= 2796	55.9

[a/] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the system.

Fig. 32.-Terminal environmental distribution of $[^{14}C]$aldrin plus metabolites in vermiculite-terrestrial model ecosystem B.

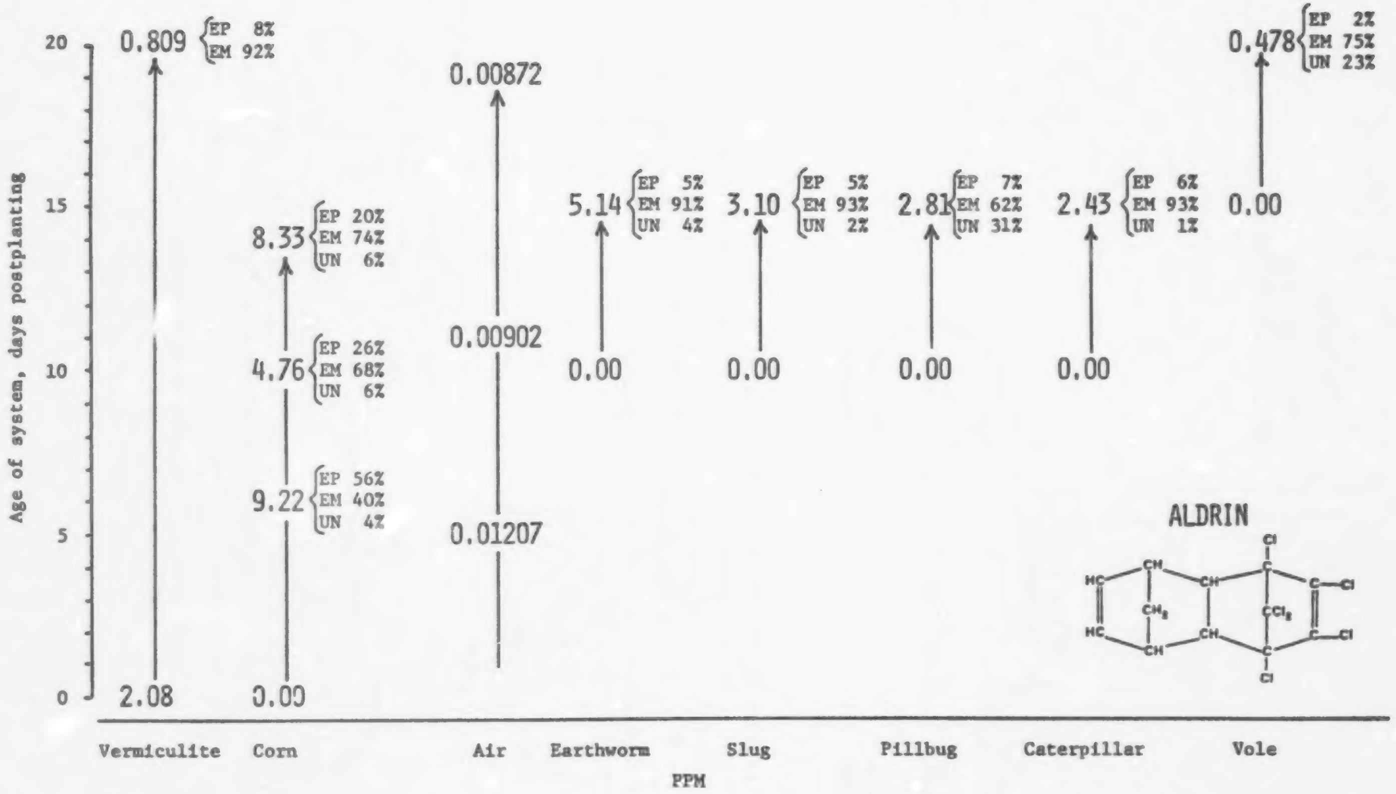


Fig. 33.—Summary of the fate of $[^{14}C]$aldrin in the vermiculite-terrestrial model ecosystem B. The total ^{14}C-residues are expressed as aldrin equivalents, ppm (w/w), and their subdivisions are: EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the vermiculite was treated with aldrin at one lb AI/acre; the invertebrates and vole were added to the system 10 and 15 days later, respectively.

Table 33.--Concentrations of [^{14}C]Aldrin and degradation products in the vermiculite substrate ("soil") of the terrestrial model ecosystem B, 20 days after applying the [^{14}C]Aldrin to the substrate.

Compounds	R_f[a]	Aldrin equivalents, ppm Acetone extract	Methanol[b] extract
Aldrin	.97	0.053	0.010
Dieldrin	.90	0.346	0.018
I[c]	.82	0.040	0.002
II	.73	0.017	
III	.69	0.010	
IV	.56	0.005	
V	.46	0.025	0.001
VI	.39	0.008	0.001
VII	.27	0.036	0.001
VIII	.17	0.009	0.001
IX	.09	0.006	0.001
X	.04	0.022	0.001
XI	.00	0.179	0.017
Total ^{14}C		0.756	0.053
Sample wt (g)		100.00	100.00

[a] Silica Gel GF-254, n-hexane : diethyl ether, 3 : 2 by volume.

[b] The methanol extract is from the sample previously extracted with acetone.

[c] Roman numerals = unknown compounds.

Table 34.—Concentrations of [^{14}C]Aldrin and degradation products in corn grown in the vermiculite-terrestrial model ecosystem B.

		Aldrin equivalents, ppm, at indicated postplanting age								
		6 Days			10 Days			14 Days		
Compound	R_f[a]	Root	Shoot	Entire plant	Root	Shoot	Entire plant	Root	Shoot	Entire plant
Aldrin	.97	6.706	0.670	5.191	2.130	0.078	1.255	3.356	0.082	1.619
Dieldrin	.87	3.707	0.344	2.863	3.532	0.077	2.060	8.556	0.081	4.061
I[b]	.74	0.207	0.377	0.249	0.377	0.173	0.288	0.939	0.182	0.538
II	.68							0.219		0.103
III	.58					0.356	0.147		0.374	0.199
IV	.48					0.325	0.134		0.341	0.182
V	.42	0.108		0.081	0.248		0.143	0.702		0.330
VI	.38					0.127	0.052		0.133	0.071
VII	.18					0.023	0.009		0.024	0.013
VIII	.16	0.044		0.033						
IX	.11	0.049		0.037	0.026		0.015	0.103		0.048
X	.06	0.082	0.043	0.072	0.013		0.007	0.132		0.062
XI	.04	0.157	0.045	0.129	0.139		0.080	0.250		0.117
XII	.00	0.232	0.067	0.190	0.340	0.233	0.291	0.731	0.245	0.474
Extractable ^{14}C		11.292	1.546	8.845	6.805	1.392	4.481	14.988	1.462	7.817
Unextractable ^{14}C		0.484	0.035	0.371	0.439	0.056	0.277	1.024	0.063	0.515
Total ^{14}C		11.776	1.581	9.216	7.244	1.448	4.758	16.012	1.525	8.332
Biosample wt (g)		1.071	0.362	1.433	0.954	0.683	1.637	0.861	0.989	1.850

[a] Silica Gel GF-254, *n*-hexane: diethyl ether, 60:40 by volume.

[b] Roman numerals = unknown compounds.

Table 35.-Concentrations of [^{14}C]Aldrin and degradation products in invertebrates after a 5-day exposure in the vermiculite-terrestrial model ecosystem B.

		Aldrin equivalents, ppm[a]			
Compound	R_f[b]	Lumbricus (worm)	Limax (slug)	Armadillidium (pillbug)	Estigmene (caterpillar)
Aldrin	.98	0.281	0.156	0.204	0.139
Dieldrin	.90	0.402	2.678	1.389	1.958
I[c]	.80	4.009	0.053	0.052	0.244
II	.65		0.026		
III	.41		0.030	0.159	
IV	.36	0.091		0.093	0.031
V	.27		0.011	0.007	
VI	.08	0.025			
VII	.04	0.077	0.034		
VIII	.00	0.069	0.039	0.045	0.018
Extractable ^{14}C		4.954	3.027	1.949	2.390
Unextractable ^{14}C		0.185	0.071	0.863	0.037
Total ^{14}C		5.139	3.098	2.812	2.427
Average bio-sample wt (g)		0.65275	0.93990	0.02050	0.82119

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[a] Average of triplicate determinations for caterpillars; average of duplicate determinations for pillbugs; single determination for worm (dead at sampling) and slug.

[b] Silica Gel GF-254, n-hexane : diethyl ether, 3 : 2 by volume.

[c] Roman numerals = unknown compounds.

Table 36.-Concentrations of [^{14}C]Aldrin and degradation products in the prairie vole after a 5-day exposure in the vermiculite-terrestrial model ecosystem

		Aldrin equivalents, ppm																
Compound	Rf[a]	Central neck gland	Uterine fat	Pectoral fat	Uterus	Stomach	Tongue	Carcass	Liver	Lungs	Parotids	Intestine	Heart	Skin	Mammary Glands	Brain	Kidneys and Adrenals	Body Totals
Aldrin	.97					0.012		0.007				0.005		0.026		0.002		0.011
Dieldrin	.94			1.693	0.772	0.481		0.381	0.382			0.196	0.340	0.025	0.170	0.072	0.004	0.267
I[b]	.84					0.011		0.056				0.004		0.005				0.029
II	.48					0.004			0.002			0.002				0.001		<0.001
III	.42					0.003			0.003			0.001	0.003					<0.001
IV	.34												0.003	0.003				0.001
V	.28													0.001				<0.001
VI	.25				0.001				0.004							0.001		<0.001
VII	.15								0.001					0.001				<0.001
VIII	.10					0.002			0.001			0.001				0.001		<0.001
IX	.05					0.005			0.001			0.002		0.001		0.004		0.001
X	.00			0.009	0.009	0.005		0.001	0.007			0.002	0.002	0.001	0.002	0.002		0.002
Extractable ^{14}C		2.601	2.149	1.702	0.782	0.523	0.696	0.445	0.401	0.450	0.375	0.212	0.348	0.063	0.172	0.083	0.004	0.367[c]
Unextractable ^{14}C		0.014	0.011	0.004	0.020	0.049	0.101	0.037	0.066	0.008	0.044	0.179	0.020	0.280	0.031	0.071	0.015	0.111
Total ^{14}C		2.615	2.160	1.706	0.802	0.572	0.797	0.482	0.467	0.458	0.419	0.391	0.368	0.343	0.203	0.154	0.019	0.478
Biosample wt (g)		0.18883	0.75345	0.54460	0.10512	1.11592	0.06855	20.30254	1.91981	0.20331	0.12110	2.85064	0.29300	11.03556	0.96418	0.58006	0.72854	41.77521

[a] Silica Gel GF-254, n-hexane : diethyl ether, 3 : 2 by volume.

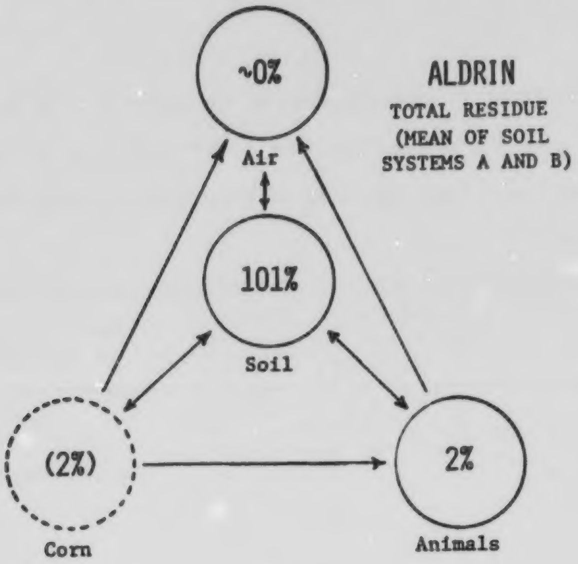
[b] Roman numerals = unknown compounds.

[c] This value represents total extractable ^{14}C in all organs; five organ extracts were not subjected to TLC separation.

Table 37.—Relative affinities of 16 body-parts of the prairie vole for $[^{14}C]$aldrin plus its metabolites, and comparisons with the relative masses of the body-parts; the vole is from vermiculite-terrestrial model ecosystem B.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass[a/]	49.04	48.60
Skin	18.97	26.42
Uterine fat	8.15	1.80
Intestines + contents	5.58	6.82
Pectoral fat	4.65	1.30
Liver	4.48	4.60
Stomach + contents	3.19	2.67
Ventral central neck gland	2.47	0.45
Mammary glands	0.98	2.31
Heart	0.55	0.70
Lungs	0.47	0.49
Brain	0.45	1.39
Uterus + ovaries	0.42	0.25
Tongue	0.28	0.16
Parotid glands	0.25	0.29
Kidneys + adrenals	0.07	1.74
	100.00	99.99

[a/] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.



Calculation of the above estimates:

Ecosystem component	Total maximum mass, g: (No.) $\overline{X}$ mass = total	Mean concentration, µg/g	Total residue, µg: (mass)(conc.)	Total residue as a % of applied dose (5000 µg)
Earthworms	(8) 3.98 = 31.8	1.26	40.1	0.8
Slugs	(8) 2.52 = 20.2	0.391	7.90	0.2
Pillbugs	(13) 0.0335 = 0.436	0.870	0.379	<0.1
Caterpillars	(8) 0.744 = 5.95	0.502	2.99	0.1
Vole	(1) 44.3 = 44.3	0.421	18.7	0.4
Animal total (I)	103		70.1	1.5
Corn[a/]	(44) 3.41 = 150	0.721	108	2.2
Soil (II)	(1)4000 = 4000	1.26	5040	101
Air		[5000 µg-(I+II)] =	-40	~0.0

a/ Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the system.

Fig. 34.-Mean terminal environmental distribution of [^{14}C]aldrin plus metabolites in soil-terrestrial model ecosystems A and B.

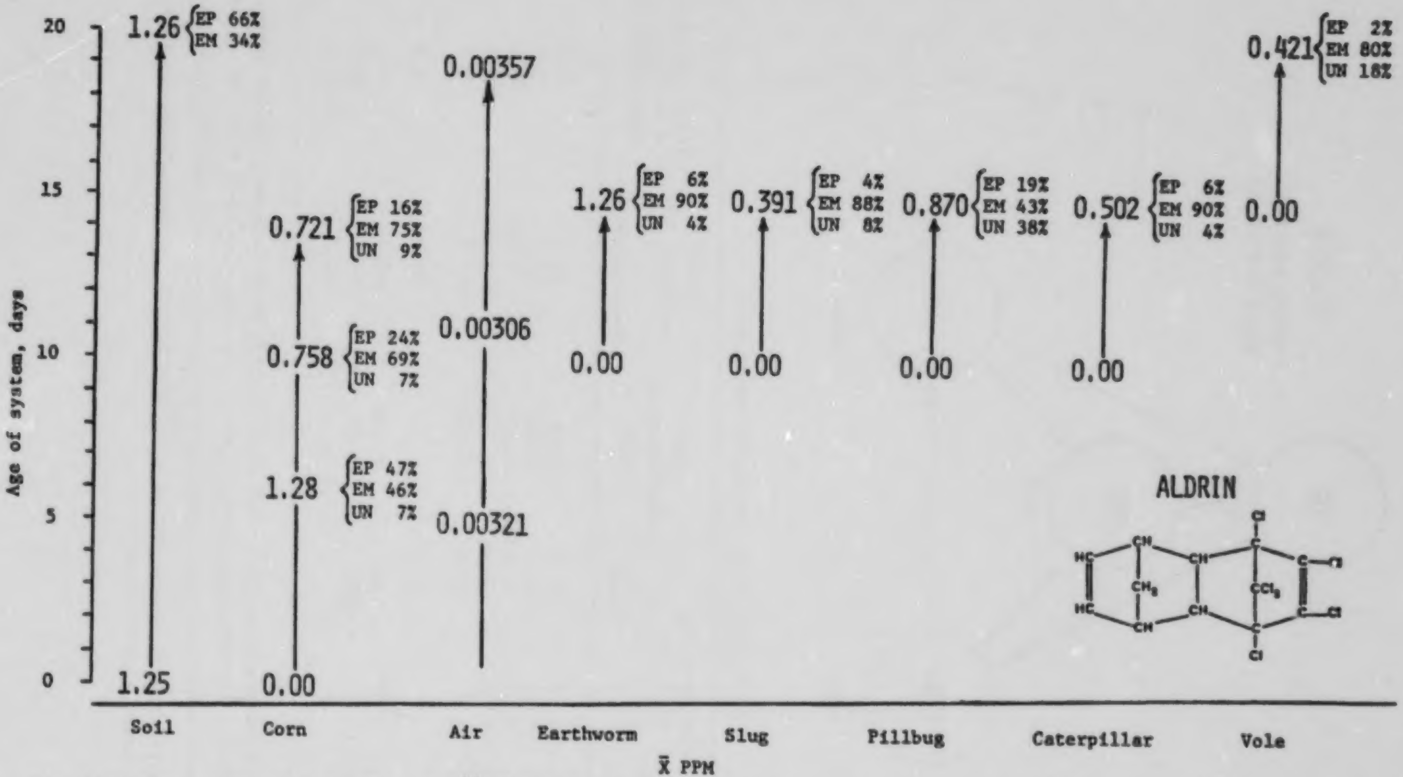
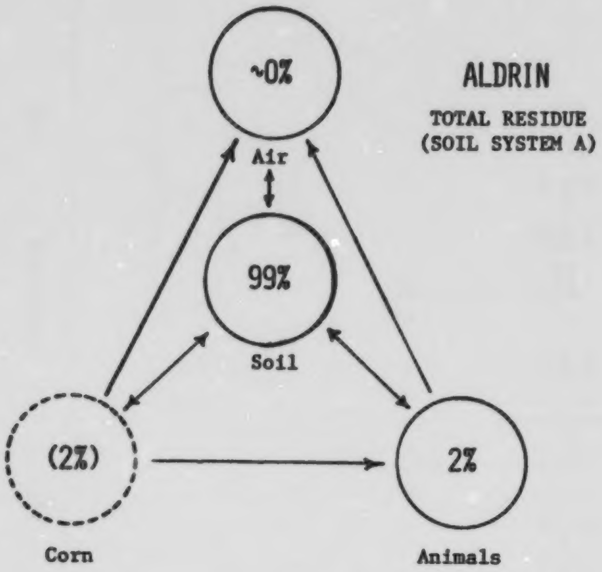


Fig. 35.—Mean summary of the fate of [^{14}C]aldrin in soil-terrestrial model ecosystems A and B. The total ^{14}C-residues are expressed as aldrin equivalents, ppm (w/w), and their subdivisions are: EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the soil was treated with aldrin at one lb AI/acre; the invertebrates and vole were added to the system 10 and 15 days later, respectively.



Calculation of the above estimates:

Ecosystem component	Total maximum mass, g: (No.)	$\overline{X}$ mass	= total	Mean concentration, μg/g	Total residue, μg: (mass)(conc.)	Total residue as a % of applied dose (5000 μg)
Earthworms	(8)	3.98	31.8	1.26	40.1	0.8
Slugs	(8)	2.52	20.2	0.513	10.4	0.2
Pillbugs	(13)	0.0335	0.436	1.29	0.562	<0.1
Caterpillars	(8)	0.744	5.95	0.523	3.11	0.1
Vole	(1)	33.7	33.7	0.633	21.3	0.4
Animal total (I)			92.1		75.5	1.5
Corn[a]	(44)	3.41	150	0.698	105	2.1
Soil (II)	(1)	4000	4000	1.24	4960	99.2
Air				[5000 μg-(I+II)] =	-35.5	~0.0

[a] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the system.

Fig. 36.-Terminal environmental distribution of [^{14}C]aldrin plus metabolites in soil-terrestrial model ecosystem A.

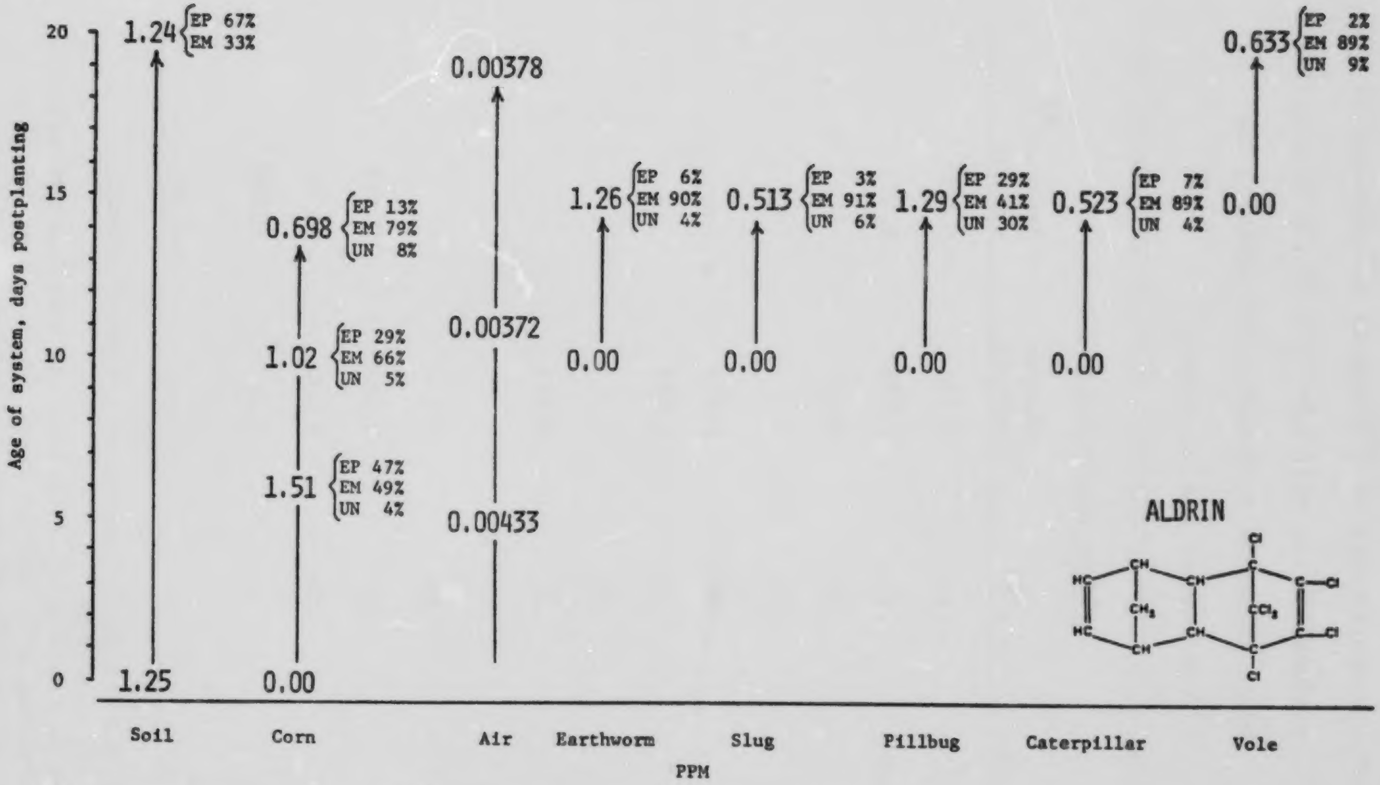


Fig. 37.—Summary of the fate of $[^{14}C]$aldrin in the soil-terrestrial model ecosystem A. The total ^{14}C-residues are expressed as aldrin equivalents, ppm (w/w), and their subdivisions are: EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the soil was treated with aldrin at one lb AI/acre; the invertebrates and vole were added to the system 10 and 15 days later, respectively.

Table 38.-Concentrations of $[^{14}C]$Aldrin and degradation products in the soil substrate of the terrestrial model ecosystem A, 20 days after applying the $[^{14}C]$Aldrin to the substrate.

		Aldrin equivalents, ppm	
Compounds	R_f[a]	Acetone extract	Methanol[b] extract
Aldrin	.97	0.830	0.002
Dieldrin	.90	0.293	0.011
I[c]	.82	0.021	
II	.73		
III	.56	0.003	
IV	.46	0.007	
V	.39		
VI	.27	0.012	
VII	.17		
VIII	.09	0.010	
IX	.04	0.007	0.002
X	.00	0.038	0.004
Total ^{14}C		1.221	0.019
Sample wt. (g)		100.00	100.00

[a] Silica Gel GF-254, n-hexane : diethyl ether, 3 : 2 by volume.

[b] The methanol extract is from the sample previously extracted with acetone.

[c] Roman numerals = unknown compounds.

Table 39.—Concentrations of $[^{14}C]$Aldrin and degradation products in corn grown in the soil-terrestrial model ecosystem A.

		Aldrin equivalents, ppm, at indicated postplanting age								
		6 Days			10 Days			14 Days		
Compound	R_f[a]	Root	Shoot	Entire plant	Root	Shoot	Entire plant	Root	Shoot	Entire plant
Aldrin	.97	1.193	0.097	0.707	0.661	0.015	0.291	0.315	0.012	0.092
Dieldrin	.87	0.896	0.064	0.527	0.784	0.023	0.348	0.987	0.018	0.275
I[b]	.74	0.106	0.056	0.084	0.143	0.040	0.085	0.155	0.031	0.063
II	.65					0.066	0.039		0.051	0.037
III	.54					0.066	0.039		0.051	0.037
IV	.42	0.027		0.015				0.034		0.009
V	.38					0.047	0.028		0.037	0.026
VI	.18					0.007	0.004		0.006	0.004
VII	.11	0.014		0.008	0.018		0.008	0.020		0.005
VIII	.06	0.015	0.009	0.013	0.038		0.016	0.010		0.003
IX	.04	0.035	0.020	0.029	0.054		0.023	0.055		0.015
X	.03		0.011	0.005						
XI	.00	0.083	0.028	0.059	0.127	0.056	0.088	0.180	0.044	0.079
Extractable ^{14}C		2.369	0.285	1.447	1.825	0.320	0.969	1.756	0.250	0.645
Unextractable ^{14}C		0.103	0.016	0.064	0.108	0.015	0.053	0.146	0.019	0.053
Total ^{14}C		2.472	0.301	1.511	1.933	0.335	1.022	1.902	0.269	0.698
Biosample wt. (g)		0.627	0.500	1.127	0.561	0.869	1.430	0.426	1.048	1.474

[a] Silica Gel GF-254, n-hexane: diethyl ether, 60:40 by volume.

[b] Roman numerals = unknown compounds.

Table 40.-Concentrations of $[^{14}C]$aldrin and degradation products in invertebrates after a 5-day exposure in the soil-terrestrial model ecosystem A

Compound	Rf[b]	Aldrin equivalents, ppm[a]			
		Lumbricus (worm)	*Limax* (slug)	*Armadillidium* (pillbug)	*Estigmene* (caterpillar)
Aldrin	.98	0.070	0.015	0.147	0.038
Dieldrin	.90	0.053	0.422	0.723	0.344
I[c]	.80	1.048	0.012		0.111
II	.73	0.003			
III	.45				0.002
IV	.27	0.010			0.001
V	.08	0.007			
VI	.04	0.005			
VII	.00	0.011	0.033		0.005
Extractable ^{14}C		1.207	0.482	0.870	0.501
Unextractable ^{14}C		0.054	0.031	0.420	0.022
Total ^{14}C		1.261	0.513	1.290	0.523
Average biosample wt (g)		3.59419	3.08918	0.03095	0.58810

[a] Average of triplicate determinations.

[b] Silica gel GF-254, *n*-hexane : diethyl ether, 3:2 by volume.

[c] Roman numerals = unknown compounds.

Table 41.-Concentrations of [^{14}C]Aldrin and degradation products in the prairie vole after a 5-day exposure in the soil-terrestrial model ecosystem A.

		Aldrin equivalents, ppm																
Compound	R_f[a]	Uterine fat	Pectoral fat	Ventral Central neck gland	Mammary glands	Uterus	Kidneys and Adrenals	Parotids	Stomach	Liver	Carcass	Heart	Skin	Intestine	Brain	Tongue	Lungs	Body Totals
Aldrin	.97	0.496					0.173				0.013							0.011
Dieldrin	.94	3.294	4.291	3.253	3.077	2.305	1.010	1.222	0.976	0.622	0.570	0.318	0.301	0.217	0.022	0.243	0.124	0.538
I[b]	.84									0.003					0.268			0.003
II	.72						0.045											0.001
III	.34	0.068			0.029		0.016								0.003			0.001
IV	.25	0.429					0.029											0.002
V	.15									0.004								<0.001
VI	.10	0.384					0.022			0.005					0.009			0.002
VII	.05						0.025			0.006								0.001
VIII	.00	0.948	0.005	0.391	0.010	0.192	0.059	0.147	0.117	0.008	0.002	0.038	0.007	0.026	0.011	0.029	0.015	0.016
Extractable ^{14}C		5.619	4.296	3.644	3.116	2.497	1.379	1.369	1.093	0.648	0.585	0.356	0.308	0.243	0.313	0.272	0.139	0.575
Unextractable ^{14}C		0.038	0.052	0.008	0.010	0.007	0.035	0.022	0.038	0.048	0.066	0.020	0.054	0.059	0.005	0.037	0.053	0.058
Total ^{14}C		5.657	4.348	3.652	3.126	2.504	1.414	1.391	1.131	0.696	0.651	0.376	0.362	0.328	0.318	0.309	0.192	0.633
Biosample wt (g)		0.08385	0.09200	0.12710	0.32452	0.07349	0.58762	0.19180	0.97168	1.65242	17.18918	0.18935	8.00861	3.60750	0.38913	0.08491	0.17119	33.74425

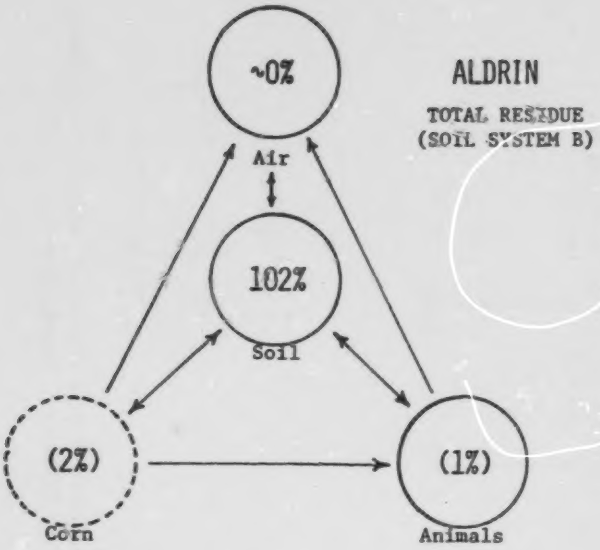
[a] Silica Gel GF-254, n-hexane - diethyl ether, 3 : 2 by volume.

[b] Roman numerals = Unknown compounds.

Table 42.—Relative affinities of 16 body-parts of the prairie vole for [^{14}C]aldrin plus its metabolites, and comparisons with the relative masses of the body-parts; the vole is from soil-terrestrial model ecosystem A.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass[a/]	52.53	50.94
Skin	13.59	23.73
Liver	5.39	4.90
Stomach + contents	5.16	2.88
Intestines + contents	5.10	10.69
Mammary glands	4.75	0.96
Kidneys + adrenals	3.90	1.74
Uterine fat	2.22	0.25
Ventral central neck gland	2.18	0.38
Pectoral fat	1.88	0.27
Parotid glands	1.25	0.57
Uterus + ovaries	0.86	0.22
Brain	0.58	1.15
Heart	0.33	0.56
Lungs	0.15	0.51
Tongue	0.12	0.25
	99.99	100.00

[a/] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.



Calculation of the above estimates:

Ecosystem component	Total maximum mass, g: (No.)	$\bar{X}$ mass	= total	Mean concentration, µg/g	Total residue, µg: (mass)(conc.)	Total residue as a % of applied dose (5000 µg)
Earthworms	(8)	3.98	= 31.8	(1.26)[a]	(40.1)[a]	(0.8)[a]
Slugs	(8)	2.52	= 20.2	0.269	5.42	0.1
Pillbugs	(13)	0.0335	= 0.436	0.450	0.196	<0.1
Caterpillars	(8)	0.744	= 5.95	0.480	2.86	0.1
Vole	(1)	54.8	= 54.8	0.208	11.4	0.2
Animal total (I)			113		(60.0)	(1.2)
Corn[b]	(44)	3.41	= 150	0.744	112	2.2
Soil (II)	(1)	4000	= 4000	1.28	5120	102
Air				[5000 µg-(I+II)]	= -180	~0.0

[a] Extrapolated from replicate aldrin-soil system.

[b] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the system.

Fig. 38.-Terminal environmental distribution of [^{14}C]aldrin plus metabolites in soil-terrestrial model ecosystem B.

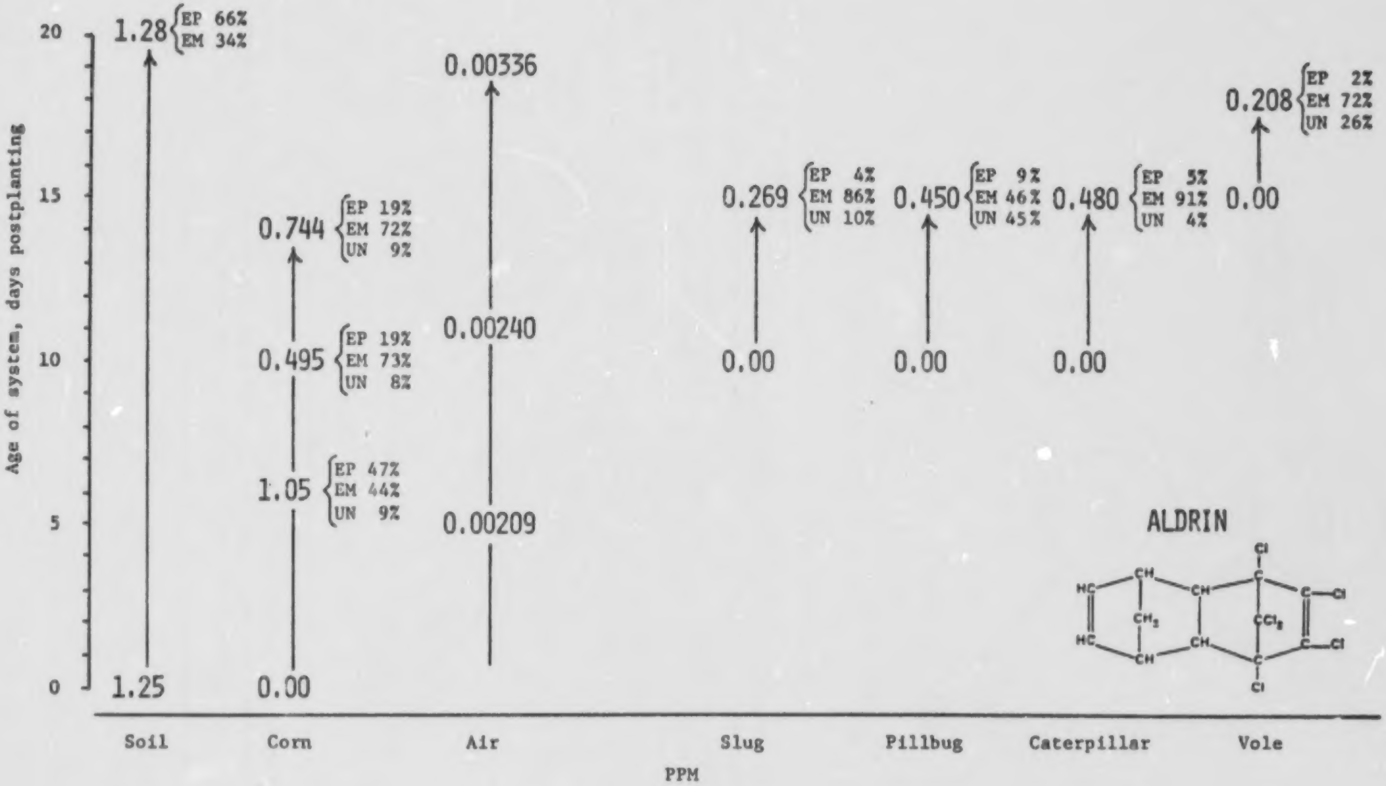


Fig. 39.—Summary of the fate of $[^{14}C]$aldrin in the soil-terrestrial model ecosystem B. The total ^{14}C-residues are expressed as aldrin equivalents, ppm (w/w), and their subdivisions are: EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the soil was treated with aldrin at one lb AI/acre; the invertebrates and vole were added to the system 10 and 15 days later, respectively. The vole died 3½ days after placing it in the system.

Table 43.-Concentrations of $[^{14}C]$Aldrin and degradation products in the soil substrate of the terrestrial model ecosystem B,20 days after applying the $[^{14}C]$Aldrin to the substrate.

		Aldrin equivalents, ppm	
Compounds	R_f[a]	Acetone extract	Methanol[b] extract
Aldrin	.97	0.846	0.003
Dieldrin	.90	0.329	0.001
I[c]	.82	0.022	
II	.73		0.001
III	.36	0.001	
IV	.46	0.004	
V	.27	0.009	
VI	.09	0.007	
VII	.04	0.012	0.004
VIII	.00	0.031	0.007
Total ^{14}C		1.261	0.016
Sample wt. (g)		100.00	100.00

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[a] Silica Gel GF=254, n-hexane : diethyl ether, 3 : 2 by volume.

[b] The methanol extract is from the sample previously extracted with acetone.

[c] Roman numerals = unknown compounds.

Table 44.—Concentrations of $[^{14}C]$Aldrin and degradation products in corn grown in the soil-terrestrial model ecosystem B.

		Aldrin equivalents, ppm, at indicated postplanting age								
		6 Days			10 Days			14 Days		
Compound	R_f[a]	Root	Shoot	Entire plant	Root	Shoot	Entire plant	Root	Shoot	Entire plant
Aldrin	.97	0.784	0.091	0.490	0.186	0.007	0.094	0.471	0.009	0.138
Dieldrin	.87	0.528	0.061	0.330	0.419	0.011	0.209	0.958	0.013	0.277
I[b]	.74	0.090	0.053	0.074	0.079	0.018	0.048	0.237	0.023	0.082
II	.65					0.030	0.016		0.037	0.027
III	.54					0.030	0.016		0.037	0.027
IV	.42	0.008		0.004				0.026		0.007
V	.38					0.022	0.012		0.026	0.019
VI	.18					0.003	0.002		0.004	0.003
VII	.11	0.011		0.006	0.009		0.004	0.027		0.008
VIII	.06	0.010	0.006	0.008	0.007		0.003	0.020		0.006
IX	.04	0.018		0.010	0.026		0.013	0.022		0.006
X	.03		0.010	0.004						
XI	.00	0.042	0.011	0.029	0.050	0.026	0.038	0.180	0.032	0.073
Extractable ^{14}C		1.491	0.232	0.955	0.776	0.147	0.455	1.941	0.181	0.673
Unextractable ^{14}C		0.142	0.037	0.094	0.067	0.015	0.040	0.195	0.022	0.071
Total ^{14}C		1.633	0.269	1.049	0.843	0.162	0.495	2.136	0.203	0.744
Biosample wt. (g)		0.839	0.575	1.414	0.809	0.902	1.711	0.514	1.324	1.838

[a] Silica Gel GF-254, _n_-hexane: diethyl ether, 60:40 by volume.

[b] Roman numerals = unknown compounds.

Table 45.-Concentrations of $[^{14}C]$Aldrin and degradation products in invertebrates after a 5-day exposure in the soil-terrestrial model ecosystem B.

Compound	R_f[b]	Aldrin equivalents, ppm[a] Limax (slug)	Armadillidium (pillbug)	Estigmene (caterpillar)
Aldrin	.98	0.010	0.042	0.025
Dieldrin	.90	0.215	0.205	0.335
I[c]	.80	0.008		0.093
II	.45			0.001
III	.27			0.002
IV	.00	0.008		0.005
Extractable ^{14}C		0.241	0.247	0.461
Unextractable ^{14}C		0.028	0.203	0.019
Total ^{14}C		0.269	0.450	0.480
Average bio-sample wt (g)		3.25515	0.06115	0.71533

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[a] Average of triplicate determinations for slugs and caterpillars; average of duplicate determinations for pillbugs.

[b] Silica Gel GF-254, n-hexane = diethyl ether, 3 : 2 by volume.

[c] Roman numerals = unknown compounds.

Table 46. -Concentrations of [^{14}C]Aldrin and degradation products in the prairie vole after a 5-day exposure in the soil-terrestrial model ecosystem B.

		Aldrin equivalents, ppm																
Compound	Rf[a/]	Pectoral fat	Mammary glands	Parotids	Uterine fat	Ventral Central neck gland	Stomach	Skin	Kidneys and Adrenals	Carcass	Uterus	Tongue	Intestine	Liver	Lungs	Heart	Brain	Body Totals
Aldrin	.97				0.032				0.016	0.005								0.004
Dieldrin	.94	0.225	0.577	0.354	0.214	0.283	0.257	0.076	0.095	0.118	0.109	0.097	0.083	0.077	0.047	0.034	0.001	0.118
I[b/]	.84	0.094								0.027							0.016	0.016
II	.72								0.004									<0.001
III	.34		0.005		0.004				0.001									<0.001
IV	.25				0.028				0.003	0.001								0.002
V	.15													0.001				<0.001
VI	.10				0.025				0.002	0.001				0.001			0.001	0.002
VII	.05								0.002	0.001				0.001				0.001
VIII	.00	0.315	0.002	0.043	0.062	0.034	0.031	0.002	0.006	0.001	0.009	0.012	0.010	0.001	0.006	0.004	0.001	0.010
Extractable ^{14}C		0.634	0.584	0.397	0.365	0.317	0.288	0.078	0.129	0.154	0.118	0.109	0.093	0.080	0.053	0.038	0.019	0.153
Unextractable ^{14}C		0.000	0.002	0.033	0.007	0.007	0.023	0.215	0.053	0.014	0.024	0.025	0.022	0.022	0.041	0.024	0.003	0.055
Total ^{14}C		0.634	0.586	0.430	0.371	0.324	0.311	0.293	0.182	0.168	0.142	0.134	0.115	0.102	0.094	0.062	0.022	0.208
Biosample wt (g)		0.72573	0.27330	0.57989	1.69602	0.77341	1.73335	10.73948	0.63659	29.43900	0.15276	0.10755	4.07904	2.25037	0.58104	0.45600	0.61419	54.83772

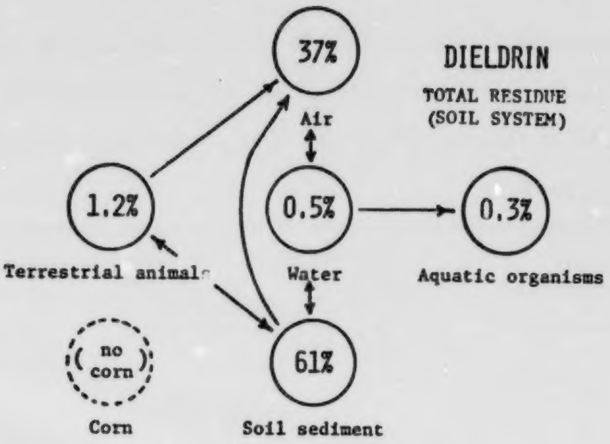
a/ Silica Gel GF-254, n-hexane : diethyl ether, 3 : 2 by volume.

b/ Roman numerals = unknown compounds.

Table 47.—Relative affinities of 16 body-parts of the prairie vole for $[^{14}C]$aldrin plus its metabolites, and comparisons with the relative masses of the body-parts; the vole is from soil-terrestrial model ecosystem B.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass[a/]	43.81	53.68
Skin	27.68	19.58
Uterine fat	5.55	3.09
Stomach + contents	4.76	3.16
Intestines + contents	4.13	7.44
Pectoral fat	4.05	1.32
Parotid glands	2.20	1.06
Ventral central neck gland	2.20	1.41
Liver	2.03	4.10
Mammary glands	1.41	0.50
Kidneys + adrenals	1.01	1.16
Lungs	0.48	1.06
Heart	0.25	0.83
Uterus + ovaries	0.19	0.28
Tongue	0.12	0.20
Brain	0.11	1.12
	99.98	99.99

[a/] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.


37%
Air
DIELDRIN
TOTAL RESIDUE
(SOIL SYSTEM)
1.2%
Terrestrial animals
0.5%
Water
0.3%
Aquatic organisms
no corn
Corn
61%
Soil sediment

Calculation of the above estimates:

Ecosystem component	Total maximum mass, g:			Mean concentration, µg/g	Total residue, µg:	Total residue as a % of applied dose (5000 µg)
	(No.)	$\bar{X}$ mass	= total		(mass)(conc.)	
Earthworms	(8)	3.85	= 30.8	0.698	21.5	0.4
Slugs	(8)	4.40	= 35.2	0.184	6.48	0.1
Pillbugs	(13)	0.060	= 0.78	0.475	0.371	<0.1
Caterpillars	(8)	0.931	= 7.45	0.275	2.05	<0.1
Vole	(1)	38.17	= 38.17	0.947	36.1	0.7
Terrestrial animal[a] total (I)			112		66.5	1.2
Corn[b]						
Algae	(3.5)	0.241	= 0.844	6.19	5.22	0.1
Snails	(50)	0.014	= 0.700	8.70	6.09	0.1
Fish	(3)	0.113	= 0.339	7.61	2.58	0.1
Aquatic organism total (II)			1.88		13.9	0.3
Surface water (III)	(1)	7000	= 7000	0.0039	27.3	0.5
Soil sediment[c] (IV)	(1)	4000	= 4000	0.762	3048	61.0
Air			[5000 µg-(I+II+III+IV)] =		1844	36.9

[a] The terrestrial animals (and their residues) were removed from the system at the termination of the terrestrial phase.

[b] No corn germinated in this model ecosystem; untreated chard and soybean plants were supplied for food.

[c] The direct interaction of air and terrestrial animals with the soil occurred prior to flooding the system.

Fig. 40.-Terminal environmental distribution of [^{14}C]dieldrin plus metabolites in a soil-terrestrial model ecosystem.

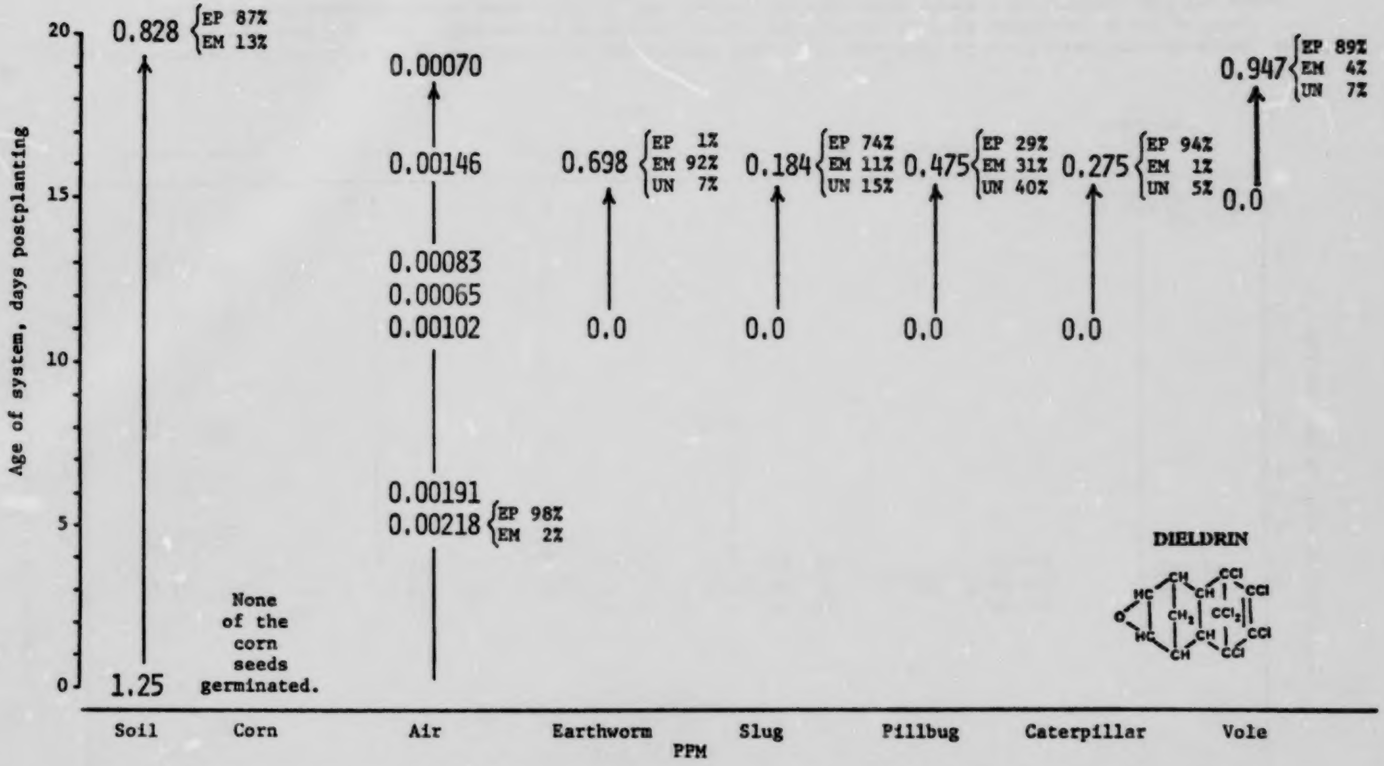


Fig. 41.—Summary of the fate of [^{14}C]dieldrin in the terrestrial phase of a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as dieldrin equivalents, ppm (w/w), and their subdivisions are: EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the soil was treated with dieldrin at one lb AI/acre. The system was drenched with water, instead of the usual sprinkling, and none of the corn seeds germinated; extraneous foliage was added later. The invertebrates and vole were added to the system 11 and 15 days later, respectively.

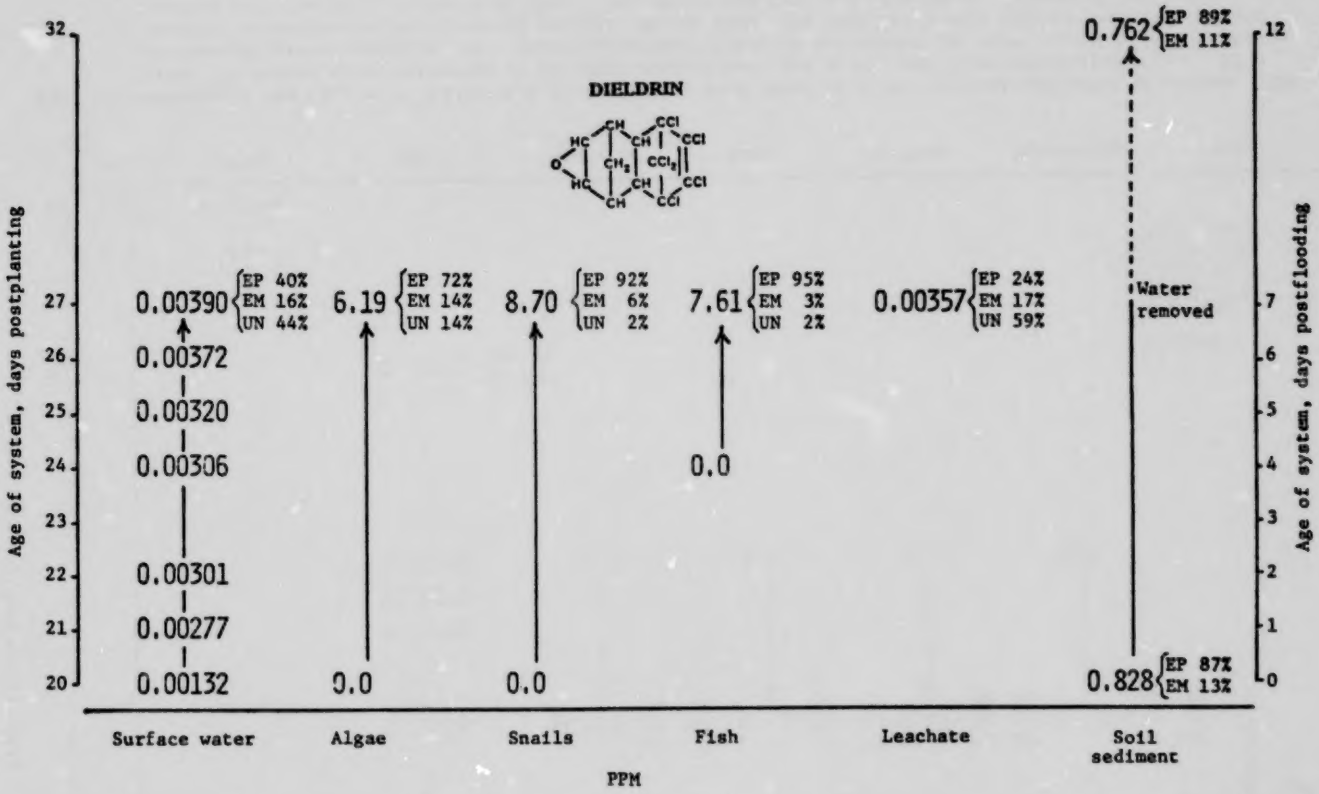


Fig. 42.—Summary of the fate of [^{14}C]dieldrin in the aquatic phase; an extension of a soil-terrestrial model ecosystem (see Fig. 41). The barren terrestrial phase was flooded 20 days postplanting and snails, Daphnia, and mosquito larvae were added to the system; the fish were added 4 days later, and the algae originated in the soil. The total ^{14}C-residues are expressed as dieldrin equivalents, ppm (w/w), and their subdivisions are: EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 48.-Concentrations of [^{14}C]dieldrin and degradation products in the soil[a/] of a model ecosystem 20 days after application of [^{14}C]dieldrin to the soil

Compound	Rf[b/]	Dieldrin equivalents, ppm	
		Acetone extract	Methanol extract[c/]
I[d/]	.93	0.0064	0.0006
II	.90	0.0256	0.0051
Dieldrin	.85	0.6068	0.1151
III	.79	0.0105	
IV	.66	0.0112	0.0022
V	.49	0.0015	0.0003
VI	.41	0.0017	0.0004
VII	.34	0.0240	0.0038
VIII	.25	0.0035	0.0006
IX	.17	0.0009	0.0002
X	.03	0.0020	0.0004
XI	.00	0.0043	0.0009
Extractable ^{14}C		0.6984	0.1296
Sample wt (g)		100.000	100.000

a/ No corn germinated in this ecosystem.

b/ Silica gel GF-254, n-hexane : diethyl ether, 3:2 by volume.

c/ Methanol extract is from the sample previously extracted with acetone.

d/ Roman numerals = unknown compounds.

Table 49.-Concentrations of $[^{14}C]$dieldrin and degradation products in the air[a] from a soil[b] model ecosystem

Compound	Rf[c]	Dieldrin equivalents, ppm	
		Trap 1[d]	Trap 2[e]
Dieldrin	.86	0.00049	
I[f]	.00	0.00001	
Total ^{14}C		0.00050	0.00168
Sum ^{14}C, Traps 1 & 2		0.00218	
Air sample wt (g) [g]		108.0	

[a] Air was trapped for a 3-hour daylight period at a flow rate of 10 ml/sec 5 days after application of $[^{14}C]$dieldrin to the soil.

[b] No corn germinated in this ecosystem.

[c] Silica gel GF-254, n-hexane : diethyl ether, 3:2 by volume.

[d] Trap 1 was connected directly to the ecosystem container and contained 75 ml of acetonitrile as the trapping solvent; the trapping solvent was chromatographed.

[e] Trap 2 was connected in series to trap 1 and contained 75 ml of trapping solvent (ethanolamine : 2-methoxyethanol, 1:2 by volume); the trap 2 solvent was not chromatographed.

[f] Roman numerals = unknown compounds.

[g] One liter of air was assumed to weigh 1 g.

Table 50.—Concentrations of [^{14}C]dieldrin and degradation products in invertebrates after a 5-day exposure in a soil[a] model ecosystem

		Dieldrin equivalents, ppm[b]			
Compound	Rf[c]	Armadillidium (pillbug)	Estigmene (caterpillar)	Limax (slug)	Lumbricus (worm)
Dieldrin	.80	0.138	0.257	0.137	0.011
I[d]	.71			0.009	0.625
II	.59				0.004
III	.36			0.005	
IV	.31			<0.001	0.004
V	.24	0.142		<0.001	0.001
VI	.09			<0.001	
VII	.03				0.004
VIII	.00	0.004	0.003	0.004	0.002
Extractable ^{14}C		0.284	0.260	0.157	0.651
Unextractable ^{14}C		0.191	0.015	0.027	0.047
Total ^{14}C		0.475	0.275	0.184	0.698
Average biosample wt (g)		0.060	0.931	4.397	3.850

[a] No corn germinated in this ecosystem; untreated soybean plants and chard were supplied for food.

[b] Average of triplicate determinations for caterpillar and slug; single determination for pillbug and worm.

[c] Silica gel GF-254, *n*-hexane : diethyl ether, 3:2 by volume.

[d] Roman numerals = unknown compounds.

Table 51.–Concentrations of [^{14}C]dieldrin and degradation products in the prairie vole after a 5-day exposure in a soil[a] model ecosystem.

		Dieldrin equivalents, ppm																	
Compound	R_f[b]	Uterine fat	Abdominal fat	Mammary glands	Ventral central Neck gland	Parotids	Pectoral fat	Skin	Kidneys and adrenals	Carcass	Uterus	Liver	Heart	Tongue	Stomach	Intestine	Lungs	Brain	Body totals
Dieldrin	.81	3.662	3.479	3.467	3.033	2.934	2.726	1.476	0.760	0.704	0.724	0.416	0.557	0.307	0.235	0.183	0.131	0.086	0.843
I[c]	.37															0.008			0.001
II	.30	0.060	0.077	0.053	0.047	0.062	0.054	0.025		0.014		0.011			0.006	0.003			0.015
III	.20	0.039	0.049	0.047	0.042	0.061	0.039	0.015		0.010		0.032							0.012
IV	.09											0.033							0.002
V	.03														0.003	0.004			0.001
VI	.00	0.002	0.015	0.003		0.010		0.001	0.016	<0.001	0.004	0.035		0.005	0.009	0.003	0.005	0.001	0.004
Extractable ^{14}C		3.763	3.620	3.570	3.122	3.067	2.819	1.517	0.776	0.729	0.728	0.527	0.557	0.312	0.253	0.201	0.136	0.087	0.878
Unextractable ^{14}C		0.015	0.030	0.025	0.022	0.049	0.012	0.266	0.025	0.039	0.024	0.065	0.022	0.033	0.028	0.047	0.028	0.006	0.069
Total ^{14}C		3.778	3.650	3.595	3.144	3.116	2.831	1.783	0.801	0.768	0.752	0.592	0.579	0.345	0.281	0.248	0.164	0.093	0.947
Biosample wt (g)		0.547	0.746	0.559	0.513	0.294	0.498	5.275	0.438	15.580	0.142	1.972	0.248	0.081	1.743	6.616	0.227	0.543	38.170[d]

[a] No corn germinated in this system; untreated soybean plants and chard were supplied for food.

[b] Silica gel GF-254, *n*-hexane : diethyl ether, 3:2 by volume.

[c] Roman numerals = unknown compounds.

[d] Live body weight.

Table 52.—Relative affinities of 17 body-parts of the prairie vole[a] for $[^{14}C]$dieldrin plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass[b]	33.13	43.25
Skin	26.04	14.64
Abdominal fat	7.53	2.07
Uterine fat	5.72	1.52
Mammary glands	5.56	1.55
Intestines + contents	4.55	18.37
Ventral central neck gland	4.46	1.42
Pectoral fat	3.90	1.38
Liver	3.23	5.47
Parotid glands	2.53	0.82
Stomach + contents	1.35	4.84
Kidneys + adrenals	0.97	1.22
Heart	0.40	0.69
Uterus	0.30	0.39
Brain	0.14	1.51
Lungs	0.10	0.63
Tongue	0.08	0.22
	99.99	99.99

[a] Vole from a soil-terrestrial model ecosystem treated with $[^{14}C]$dieldrin.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

Table 53.-Concentrations of [^{14}C]dieldrin and degradation products in the water of a soil[a] model ecosystem 7 days after flooding the ecosystem with water[b]

Compound	Rf[d]	Dieldrin equivalents, ppm			
		Surface water		Leachate[c]	
		Ether-extractable before hydrolysis	Ether-extractable after hydrolysis[e]	Ether-extractable before hydrolysis	Ether-extractable after hydrolysis
I[f]	.93	0.00005			
Dieldrin	.88	0.00157	0.00001	0.00087	0.00008
II	.72	0.00002			
III	.56			0.00002	
IV	.49	0.00002			
V	.46	0.00015		0.00004	
VI	.39	0.00008			
VII	.34	0.00012			
VIII	.30			0.00024	
IX	.20		0.00001	0.00007	
X	.12			0.00007	
XI	.09				0.00004
XII	.07	0.00004	0.00002		0.00006
XIII	.05		0.00005		0.00031
XIV	.03	0.00004	0.00025	0.00003	0.00032
XV	.00	0.00008	0.00042	0.00012	0.00022
Extractable ^{14}C		0.00217	0.00076	0.00146	0.00103
Unextractable ^{14}C			0.00047	0.00192	0.00066
Total extractable ^{14}C		0.00293		0.00249	
Unextractable ^{14}C after hydrolysis		0.00047		0.00066	
^{14}C loss during hydrolysis		0.00050		0.00042	
Initial ^{14}C in water		0.00390		0.00357	
Sample volume (1)		1.000		1.000	

[a] No corn germinated in this ecosystem.
[b] Ecosystem was flooded with water 20 days after application of [^{14}C]dieldrin to the soil.
[c] One liter of water was withdrawn through the tap at the jar bottom over a period of about 24 hours.
[d] Silica gel GF-254, n-hexane : diethyl ether, 3:2 by volume.
[e] The "unextractable" of the preceding column was adjusted to 0.012 N HCl and maintained at 55-56°C for 18-24 hr.
[f] Roman numerals = unknown compounds.

Table 54.-Concentrations of [^{14}C]dieldrin and degradation products in aquatic organisms of a soil[a] model ecosystem flooded with water[b]

Compound	Rf[d]	Dieldrin equivalents, ppm[c]		
		Gambusia[e] (fish)	Physa[f] (snail)	Algae[g]
I[h]	.92			0.068
II	.89		0.349	
Dieldrin	.83	7.253	8.018	4.426
III	.79			0.632
IV	.31	0.212	0.182	0.147
V	.00	0.027	0.016	0.036
Extractable ^{14}C		7.492	8.565	5.309
Unextractable ^{14}C		0.118	0.130	0.880
Total ^{14}C		7.610	8.695	6.189
Average bio-sample wt (g)		0.113	0.014	0.241

[a] No corn germinated in this system.

[b] Ecosystem was flooded with water 20 days after application of [^{14}C]dieldrin to the soil.

[c] Average of triplicate determinations for fish; average of duplicate determinations for snails; single determination for algae.

[d] Silica gel GF-254, *n*-hexane : diethyl ether, 3:2 by volume.

[e] Fish were added 4 days after flooding the ecosystem, removed 3 days later, and processed individually.

[f] Snails were added on the day of flooding, removed 7 days later, and processed in 2 batches of 15 snails each; average batch weight = 0.204 g.

[g] Algae were filtered from the surface water 7 days after flooding the ecosystem.

[h] Roman numerals = unknown compounds.

Table 55.-Concentrations of $[^{14}C]$dieldrin and degradation products in the soil[a/] sediment of a model ecosystem 12 days after flooding the ecosystem with water[b/]

Compound	Rf[c/]	Dieldrin equivalents, ppm	
		Acetone extract	Methanol extract[d/]
I[e/]	.93	0.0041	0.0007
II	.90	0.0183	0.0022
Dieldrin	.85	0.6062	0.0716
III	.79	0.0054	0.0005
IV	.66	0.0107	0.0012
V	.49	0.0058	0.0005
VI	.41	0.0040	0.0002
VII	.34	0.0108	0.0013
VIII	.31	0.0032	
IX	.25	0.0037	0.0005
X	.17	0.0026	0.0003
XI	.03	0.0022	0.0003
XII	.00	0.0049	0.0007
Extractable ^{14}C		0.6819	0.0800
Sample wt (g)		100.000	100.000

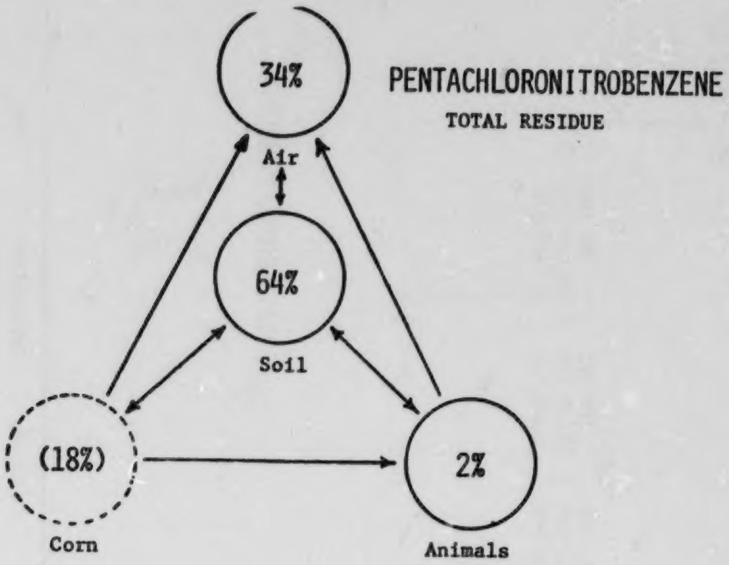
[a/] No corn germinated in this ecosystem.

[b/] Ecosystem was flooded with water 20 days after application of $[^{14}C]$dieldrin to the soil.

[c/] Silica gel GF-254, *n*-hexane : diethyl ether, 3:2 by volume.

[d/] Methanol extract is from the sample previously extracted with acetone.

[e/] Roman numerals = unknown compounds.



Calculation of the above estimates:

Ecosystem component	Total maximum mass, g:			Mean concentration, μg/g	Total residue, μg:	Total residue as a % of applied dose (5000 μg)
	(No.)	$\overline{X}$ mass	= total		(mass)(conc.)	
Earthworms	(8)	3.36	= 26.9	1.39	37.4	0.7
Slugs	(4)	9.09	= 36.4	0.441	16.0	0.3
Pillbugs	(13)	0.0333	= 0.433	1.77	0.766	<0.1
Caterpillars	(8)	0.890	= 7.12	2.44	17.4	0.3
Vole	(1)	25.5	= 25.5	0.677	17.3	0.3
Animal total (I)			96.4		88.9	1.6
Corn[a]	(28)	3.39	= 94.9	9.25	878	17.6
Soil (II)	(1)	3718	= 3718	0.858	3190	63.8
Air				[5000 μg-(I+II)] =	1721	34.4

[a] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the system.

Fig. 43.-Terminal environmental distribution of $[^{14}C]$pentachloronitrobenzene plus metabolites in a soil-terrestrial model ecosystem.

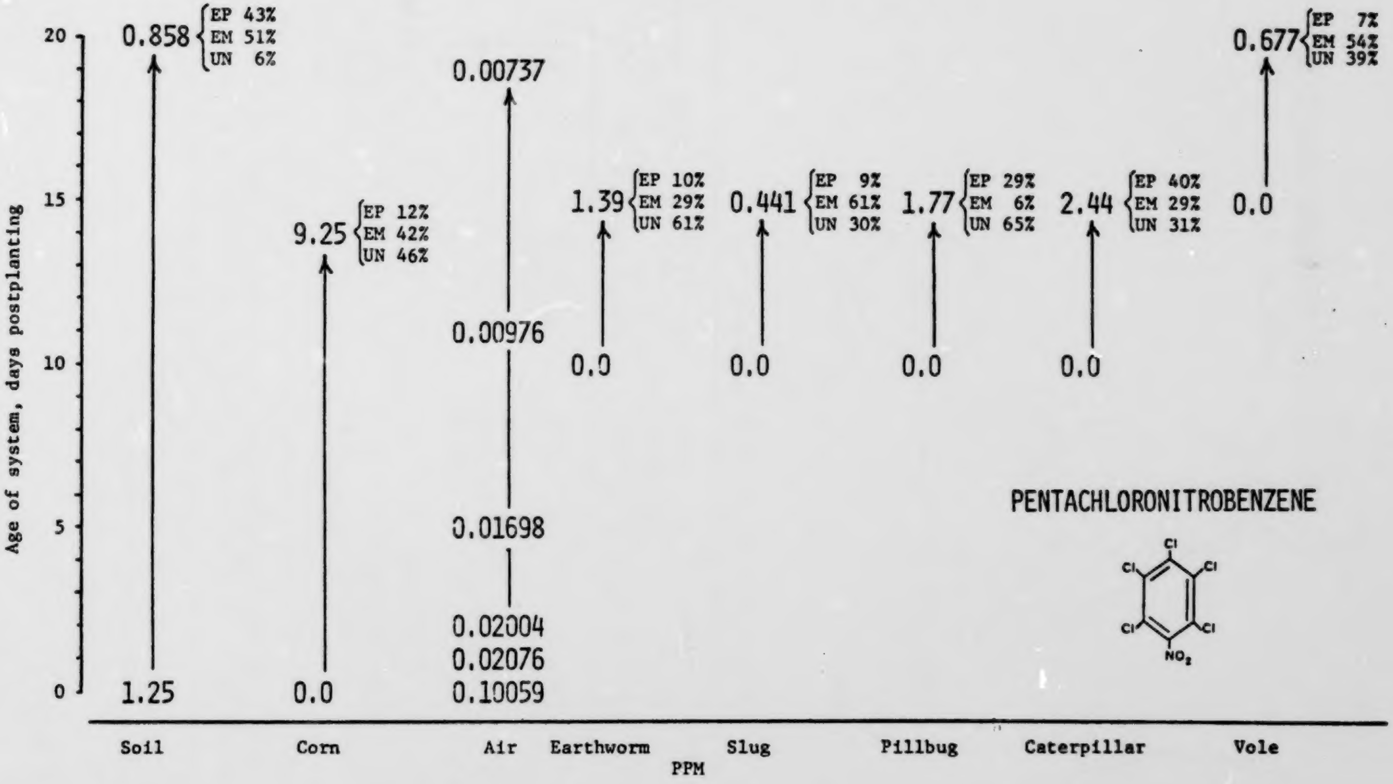


Fig. 44.—Summary of the fate of [^{14}C]pentachloronitrobenzene in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as pentachloronitrobenzene equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the soil was treated with pentachloronitrobenzene at one lb AI/acre. On days 10 and 15, the invertebrates and the vole were added, respectively.

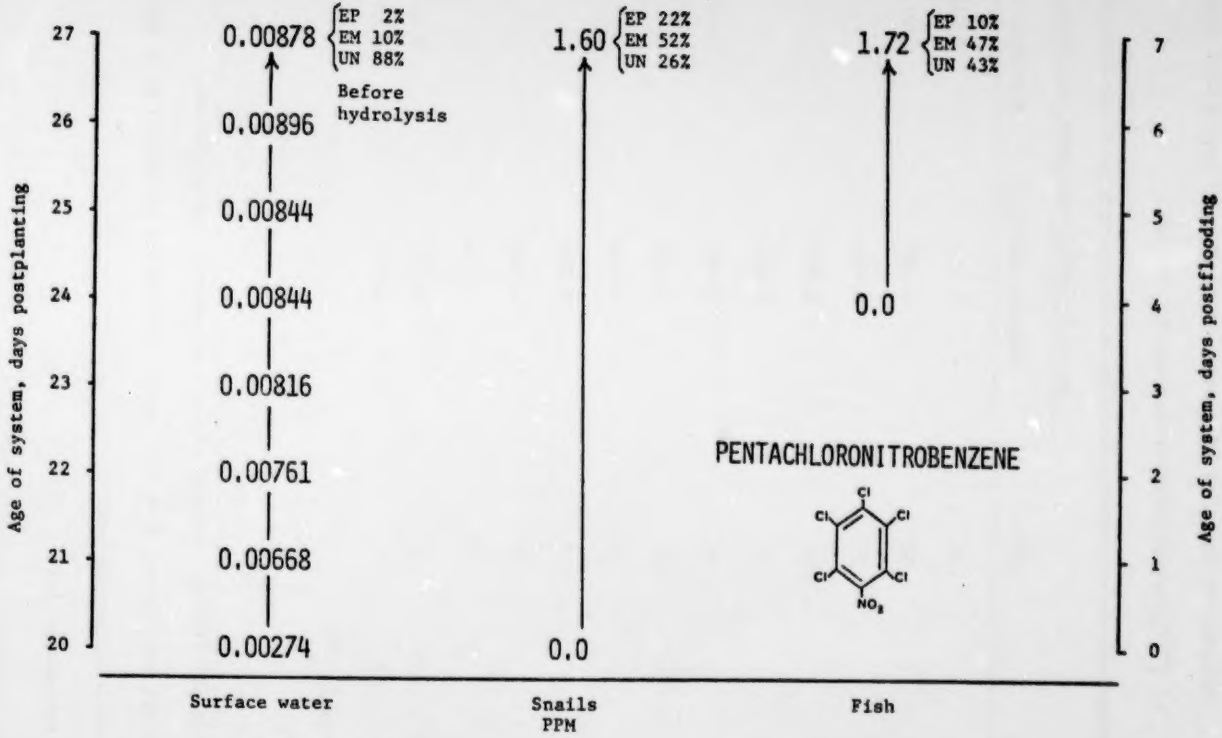


Fig. 45.—Summary of the fate of $[^{14}C]$pentachloronitrobenzene in the aquatic phase; an extension of a soil-terrestrial model ecosystem (see Fig. 44). The barren terrestrial phase was flooded 20 days postplanting and snails, Daphnia, and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as pentachloronitrobenzene equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 56.-Concentrations of [^{14}C]pentachloronitrobenzene and degradation products in the soil of a model ecosystem 20 days after application of [^{14}C]pentachloronitrobenzene to the soil

		Pentachloronitrobenzene equivalents, ppm	
Compound	Rf[a]	Acetone extract	Methanol extract[b]
PCNB[c]	.98	0.351	0.018
PCA[d]	.91	0.117	0.011
I[e]	.75	0.024	
II	.62	0.006	
III	.49	0.010	
IV	.46	0.092	0.009
V	.33	0.004	
VI	.25	0.005	
VII	.18	0.010	
VIII	.10	0.010	
IX	.03	0.029	
X	.00	0.078	0.035
Extractable ^{14}C		0.736	0.073
Unextractable ^{14}C		0.049	
Total ^{14}C		0.858	
Sample wt (g)		100.000	

a/ Silica gel GF-254, diethyl ether : *n*-hexane, 7:3 by volume.

b/ Methanol extract is from the sample previously extracted with acetone.

c/ Pentachloronitrobenzene.

d/ Pentachloroaniline.

e/ Roman numerals = unknown compounds.

Table 57.-Concentrations of [^{14}C]pentachloronitrobenzene and degradation products in corn[a] after a 14-day exposure in a model ecosystem

		Pentachloronitrobenzene equivalents, ppm[b]		
Compound	Rf[c]	Root	Shoot	Entire plant
PCNB[d]	0.97	2.649	0.098	1.081
PCA[e]	0.88	2.043	0.036	0.815
I[f]	0.46	0.538	0.020	0.219
II	0.22		0.001	0.001
III	0.19	0.119	0.002	0.047
IV	0.11	0.140	0.009	0.060
V	0.05	0.220	0.021	0.095
VI	0.00	7.369	0.098	2.706
Extractable ^{14}C		13.078	0.285	5.024
Unextractable ^{14}C		10.612	0.477	4.223
Total ^{14}C		23.690	0.762	9.247
Average bio-sample wt (g)		0.715	1.334	2.049

[a] [^{14}C]Pentachloronitrobenzene was applied to the soil beneath each seed.

[b] Average of triplicate determinations.

[c] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

[d] Pentachloronitrobenzene.

[e] Pentachloroaniline.

[f] Roman numerals = unknown compounds.

Table 58.-Concentrations of $[^{14}C]$pentachloronitrobenzene and degradation products in invertebrates after a 5-day exposure in a model ecosystem

Compound	Rf[b]	Pentachloronitrobenzene equivalents, ppm[a]			
		Armadillidium[c] (pillbug)	Estigmene (caterpillar)	Limax (slug)	Lumbricus (worm)
PCNB[d]	.94	0.511	0.973	0.042	0.146
PCA[e]	.84	0.033	0.588	0.032	0.037
I[f]	.40		0.014		0.015
II	.29			0.005	
III	.14			0.051	0.111
IV	.06	<0.001		0.030	0.053
V	.03	0.010	0.014	0.013	0.061
VI	.00	0.063	0.101	0.137	0.125
Extractable ^{14}C		0.617	1.690	0.310	0.548
Unextractable ^{14}C		1.152	0.748	0.131	0.844
Total ^{14}C		1.769	2.438	0.441	1.392
Average bio-sample wt (g)		0.033	0.890	9.092	3.355

[a] Average of duplicate determinations for caterpillars and worms; single determination for pillbugs and slug.

[b] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

[c] Three pillbugs were processed together; batch weight = 0.100 g.

[d] Pentachloronitrobenzene.

[e] Pentachloroaniline.

[f] Roman numerals = unknown compounds.

Table 59.-Concentrations of [^{14}C]pentachloronitrobenzene and degradation products in the prairie vole after a 5-day exposure in a model ecosystem

		Pentachloronitrobenzene equivalents, ppm							
Compound	Rf[a]	Remaining organs[b]	Uterine fat	Skin	Uterus	Liver	Brain	Carcass	Body totals[c]
PCNB[d]	.96	0.139	0.038	0.051	0.092	0.018	0.037	0.024	0.051
PCA[e]	.82	0.753	0.634	0.266	0.231	0.137	0.045	0.091	0.251
I[f]	.76						0.117		0.003
II	.55		0.004						<0.001
III	.46	0.027		0.012				0.002	0.009
IV	.20	0.018							0.003
V	.19			0.005				0.002	0.002
VI	.12			0.006				0.003	0.002
VII	.05	0.107		0.006		0.037	0.012	0.001	0.025
VIII	.00	0.320	0.007	0.011	0.045	0.029	0.013	0.003	0.070
Extractable ^{14}C		1.364	0.683	0.357	0.368	0.221	0.224	0.126	0.416
Unextractable ^{14}C		0.912	0.035	0.320	0.078	0.175	0.012	0.038	0.261
Total ^{14}C		2.276	0.718	0.677	0.446	0.396	0.236	0.164	0.677
Biosample wt (g)		5.155	0.130	3.729	0.019	1.364	0.585	13.594	

[a] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.
[b] Internal organs, other than those specified, were combined and processed as an individual sample.
[c] Body totals were calculated using live body weight (25.527 g).
[d] Pentachloronitrobenzene.
[e] Pentachloroaniline.
[f] Roman numerals = unknown compounds.

Table 60.—Relative affinities of 7 body-parts of the prairie vole[a] for $[^{14}C]$pentachloronitrobenzene plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Skin	14.62	15.17
Carcass[b]	12.89	55.31
Liver	3.13	5.55
Brain	0.80	2.38
Uterine fat	0.54	0.53
Uterus	0.05	0.08
Remaining organs[c]	67.96	20.98
	99.99	100.00

[a] Vole from a soil-terrestrial model ecosystem treated with $[^{14}C]$pentachloronitrobenzene.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

[c] The gastrointestinal tract + contents, kidneys + adrenals, heart, lungs, mammary glands, ventral central neck gland, parotid glands and small amounts of fat tissue were analyzed collectively; most (ca. 3/4) of the mass consisted of the gastrointestinal tract + contents.

Table 61.-Concentrations of [^{14}C]pentachloronitrobenzene and degradation products in the water of a model ecosystem 7 days after flooding the ecosystem with water[a]

		Pentachloronitrobenzene equivalents, ppm	
Compound	Rf[b]	Ether-extractable before hydrolysis	Ether-extractable after hydrolysis[c]
PCNB[d]	.96	0.00015	0.00017
PCA[e]	.84	0.00034	0.00027
I[f]	.68	0.00007	
II	.59	0.00003	
III	.46	0.00003	
IV	.44	0.00023	0.00004
V	.33	0.00002	
VI	.23	0.00002	
VII	.20		0.00002
VIII	.16		0.00004
IX	.10	0.00005	0.00043
X	.09		0.00024
XI	.07		0.00006
XII	.05		0.00006
XIII	.04		0.00003
XIV	.02	0.00004	0.00006
XV	.00	0.00008	0.00063
Extractable ^{14}C		0.00106	0.00205
Unextractable ^{14}C		0.00760	0.00484
Total extractable ^{14}C			0.00311
Unextractable ^{14}C after hydrolysis			0.00484
^{14}C loss during hydrolysis			0.00083
Initial ^{14}C in water			0.00878
Sample volume (l)			1.000

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[a] Ecosystem was flooded with water 20 days after application of [^{14}C]pentachloronitrobenzene to the soil.

[b] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

[c] The "unextractable" of the preceding column was adjusted to 0.012 N HCl and maintained at 55-56°C for 18-24 hours.

[d] Pentachloronitrobenzene.

[e] Pentachloroaniline.

[f] Roman numerals = unknown compounds.

Table 62.-Concentrations of $[^{14}C]$pentachloronitrobenzene and degradation products in aquatic organisms in a model ecosystem flooded with water[a]

Compound	Rf[c]	Pentachloronitrobenzene equivalents, ppm[b]	
		Gambusia[d] (fish)	Physa[e] (snail)
PCNB[f]	.92	0.171	0.350
PCA[g]	.79	0.684	0.544
I[h]	.65		0.026
II	.45	0.062	0.096
III	.06	0.007	0.039
IV	.00	0.060	0.133
Extractable ^{14}C		0.984	1.188
Unextractable ^{14}C		0.734	0.413
Total ^{14}C		1.718	1.601
Average bio-sample wt (g)		0.343	0.012

[a] Ecosystem was flooded with water 20 days after application of $[^{14}C]$pentachloronitrobenzene to the soil.

[b] Average of triplicate determinations for fish; single determination for snails.

[c] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

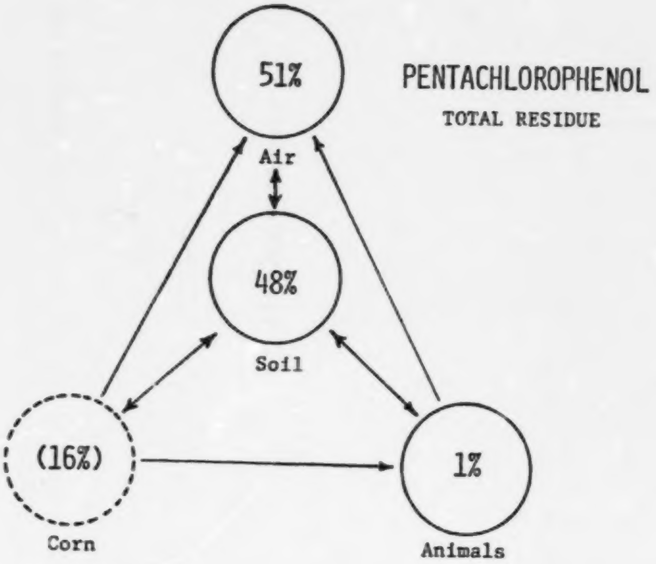
[d] Fish were added 4 days after flooding the ecosystem, removed 3 days later, and processed individually.

[e] Snails were added on the day of flooding; 15 snails were removed 7 days later and processed as single batch; batch weight = 0.183 g.

[f] Pentachloronitrobenzene.

[g] Pentachloroaniline.

[h] Roman numerals = unknown compounds.



Calculation of the above estimates:

Ecosystem component	Total maximum mass, g:			Mean concentration, µg/g	Total residue, µg:	Total residue as a % of applied dose (5000 µg)
	(No.)	$\overline{X}$ mass	= total		(mass)(conc.)	
Earthworms	(8)	3.78	= 30.2	0.551	16.7	0.3
Slugs	(4)	6.31	= 25.2	0.212	5.35	0.1
Pillbugs	(13)	0.033	= 0.429	0.618	0.265	<0.1
Caterpillars	(8)	0.937	= 7.50	1.45	10.9	0.2
Vole	(1)	45.5	= 45.5	0.530	24.1	0.5
Animal total (I)			109		57.3	1.1
Corn[a]	(38)	3.39	= 129	6.30	812	16.2
Soil (II)	(1)	3766	= 3766	0.634	2388	47.8
Air				[5000 µg-(I+II)] =	2555	51.1

[a] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the system.

Fig. 46.-Terminal environmental distribution of $[^{14}C]$pentachlorophenol plus metabolites in a soil-terrestrial model ecosystem.

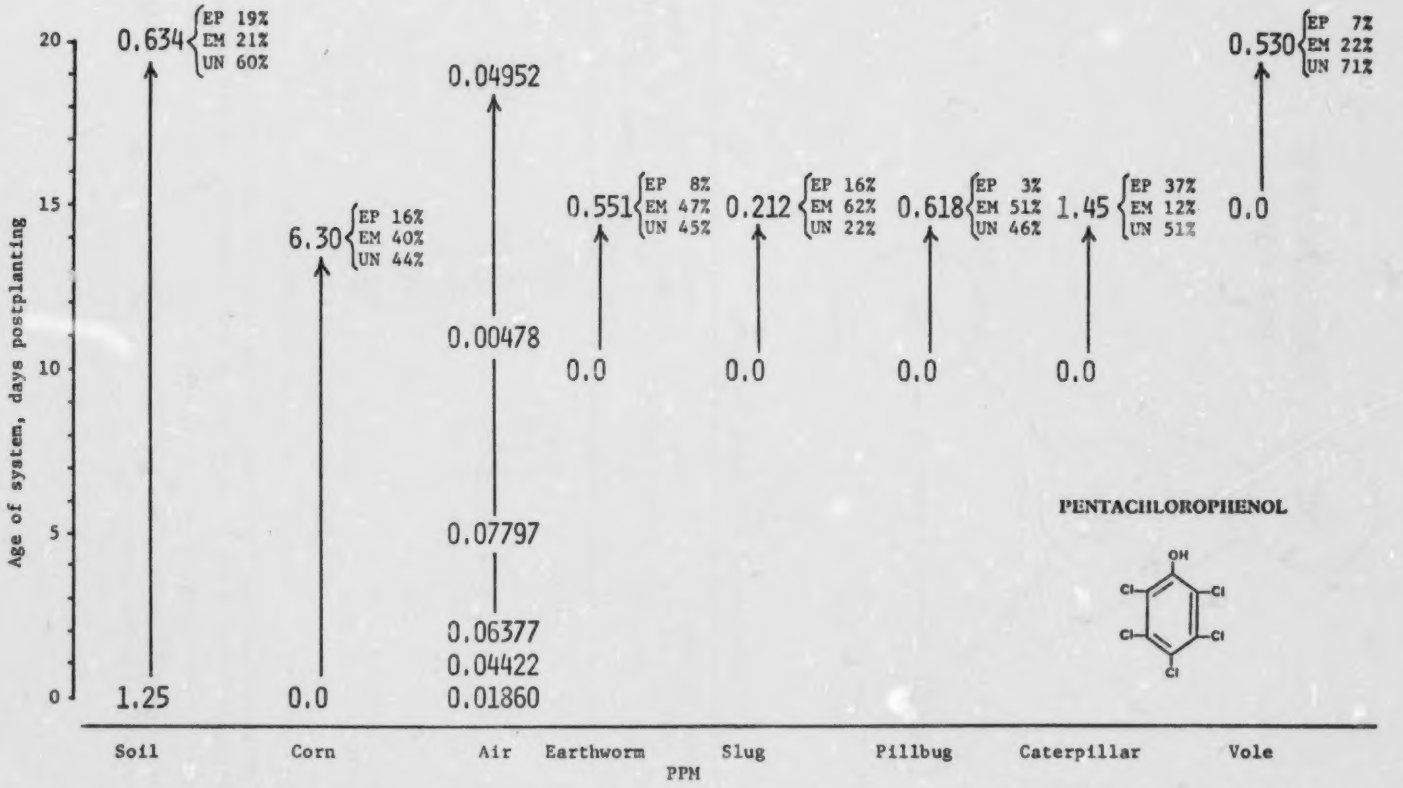


Fig. 47.—Summary of the fate of [^{14}C]pentachlorophenol in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as pentachlorophenol equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the soil was treated with pentachlorophenol at one lb AI/acre. On days 10 and 15, the invertebrates and the vole were added, respectively.

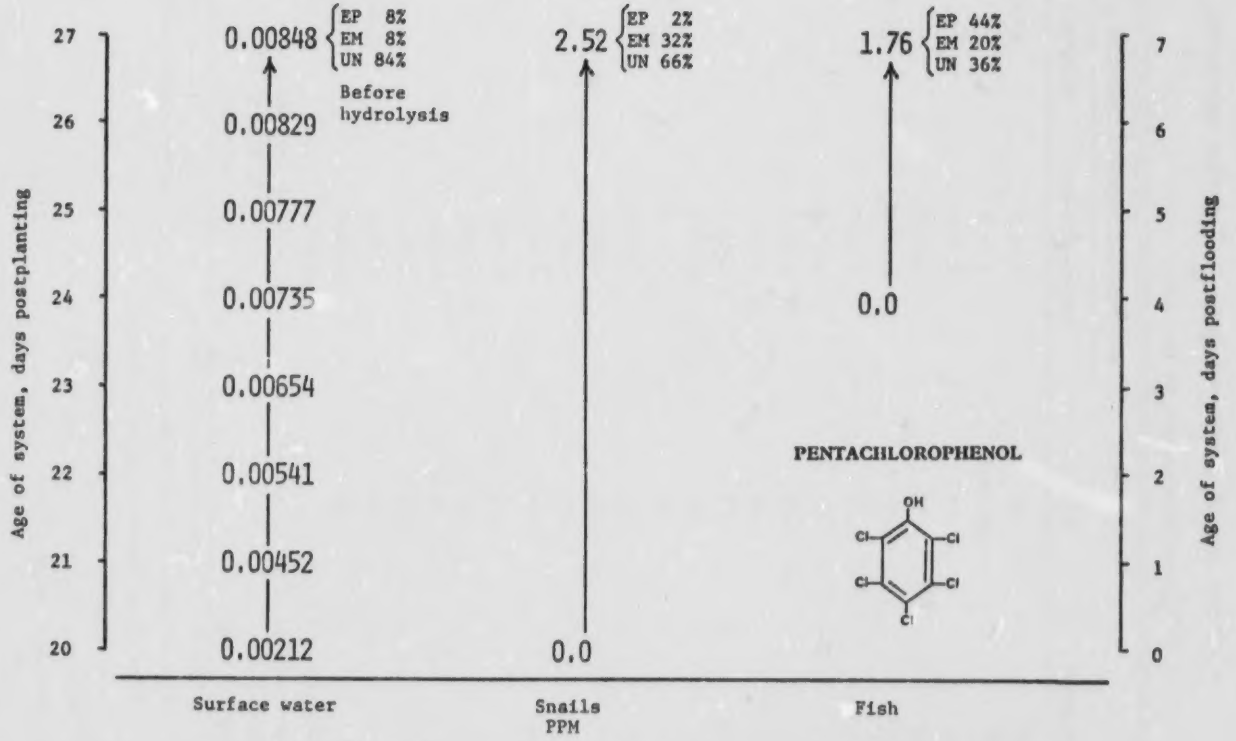


Fig. 48.—Summary of the fate of [^{14}C]pentachlorophenol in the aquatic phase; an extension of a soil-terrestrial model ecosystem (see Fig. 47). The barren terrestrial phase was flooded 20 days postplanting, and snails, Daphnia and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as pentachlorophenol equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 63.-Concentrations of $[^{14}C]$pentachlorophenol and degradation products in the soil of a model ecosystem 20 days after application of $[^{14}C]$pentachlorophenol to the soil

		Pentachlorophenol equivalents, ppm	
Compound	Rf[a]	Acetone extract	Methanol extract[b]
A[c]	.93	0.0233	0.0019
I[d]	.83-.90[e]	0.0053	
II	.81	0.0104	
III	.78	0.0320	
PCP[f]	.72	0.0939	0.0252
IV	.58	0.0038	
V	.51	0.0018	
VI	.49	0.0023	
VII	.46	0.0012	
VIII	.45	0.0012	
IX	.43	0.0017	
X	.38	0.0032	
XI	.34	0.0009	
XII	.32	0.0007	
XIII	.30	0.0004	
XIV	.26	0.0021	
XV	.21	0.0013	
XVI	.18	0.0007	
XVII	.14	0.0020	
XVIII	.07	0.0055	
XIX	.04	0.0062	0.0031
XX	.00	0.0155	0.0101
Extractable ^{14}C		0.2154	0.0403
Unextractable ^{14}C		0.3780	
Total ^{14}C		0.6337	
Sample wt (g)		100.0000	

[a] Silica gel GF-254, benzene : *n*-hexane : acetic acid, 90:5:5 by volume.

[b] Methanol extract is from the sample previously extracted with acetone.

[c] Chloranil (tetrachloro-*p*-benzoquinone).

[d] Roman numerals = unknown compounds.

[e] Rf range denotes a streak on the TLC plate.

[f] Pentachlorophenol.

Table 64.-Concentrations of [^{14}C]pentachlorophenol and degradation products in corn[a] after a 14-day exposure in a model ecosystem

Compound	Rf[c]	Pentachlorophenol equivalents, ppm[b]		
		Root	Shoot	Entire plant
A[d]	.93	0.264	0.008	0.076
I[e]	.89	0.051		0.013
PCP[f]	.75	2.680	0.020	1.007
II	.62	0.018	0.137	0.098
III	.56	0.042	0.014	0.025
IV	.45		0.003	0.002
V	.44	0.015	0.037	0.028
VI	.38	0.048	0.055	0.048
VII	.29	0.034	0.022	0.029
VIII	.18		0.032	0.021
IX	.11	0.070	0.065	0.058
X	.04	0.204	0.120	0.164
XI	.00	4.490	0.151	1.935
Extractable ^{14}C		7.916	0.664	3.504
Unextractable ^{14}C		4.779	1.654	2.791
Total ^{14}C		12.695	2.318	6.295
Average bio-sample wt (g)		0.581	1.120	1.701

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[a] [^{14}C]Pentachlorophenol was applied to the soil beneath each seed.

[b] Average of triplicate determinations.

[c] Silica gel GF-254, benzene : *n*-hexane : acetic acid, 90:5:5 by volume.

[d] Chloranil (tetrachloro-*p*-benzoquinone).

[e] Roman numerals = unknwon compounds.

[f] Pentachlorophenol.

Table 65.-Concentrations of $[^{14}C]$pentachlorophenol and degradation products in invertebrates after a 5-day exposure in a model ecosystem

		Pentachlorophenol equivalents, ppm[a]			
Compound	Rf[b]	Armadillidium[c] (pillbug)	Estigmene (caterpillar)	Limax (slug)	Lumbricus (worm)
A[d]	.94	0.225	0.041		0.026
I[e]	.76-.87[f]				0.029
PCP[g]	.73	0.022	0.541	0.035	0.046
II	.26-.65				0.080
III	.60		0.048		
IV	.46		0.027		
V	.23		0.020	0.003	0.063
VI	.11		0.011		0.038
VII	.04	0.002	0.005	0.104	
VIII	.00	0.086	0.027	0.024	0.022
Extractable ^{14}C		0.335	0.720	0.166	0.304
Unextractable ^{14}C		0.283	0.734	0.046	0.247
Total ^{14}C		0.618	1.454	0.212	0.551
Average bio-sample wt (g)		0.033	0.937	6.311	3.776

[a] Average of duplicate determinations for caterpillars and worms; single determination for pillbugs and slug.

[b] Silica gel GF-254, benzene : *n*-hexane : acetic acid, 90:5:5 by volume.

[c] Three pillbugs were processed together; batch weight = 0.099 g.

[d] Chloranil (tetrachloro-*p*-benzoquinone).

[e] Roman numerals = unknown compounds.

[f] Rf range denotes a streak on the TLC plate.

[g] Pentachlorophenol.

Table 66.-Concentrations of [^{14}C]pentachlorophenol and degradation products in the prairie vole after a 5-day exposure in a model ecosystem

Compound	Rf[a]	Pentachlorophenol equivalents, ppm							
		Liver	Remaining organs[b]	Brain	Uterus	Skin	Carcass	Uterine fat	Body totals[c]
A[d]	.95			0.008		0.015	0.008	0.007	0.006
I[e]	.78							0.002	<0.001
II	.76						0.006	0.069	0.003
PCP[f]	.66	0.034	0.045	0.044	0.135	0.026	0.037	0.014	0.037
III	.53		0.018	0.053	0.052	0.026	0.004	0.008	0.012
IV	.46	0.009	0.017	0.060	0.008	0.007	0.008		0.011
V	.42		0.012			0.004	0.003		0.006
VI	.12-.40[g]			0.069		0.011	0.010		0.006
VII	.31		0.004						0.001
VIII	.23		0.030						0.010
IX	.12		0.023				0.003		0.009
X	.05	0.024	0.033	0.020	0.006	0.006	0.004		0.015
XI	.00	0.259	0.056	0.023	0.014	0.009	0.006		0.037
Extractable ^{14}C		0.326	0.238	0.277	0.215	0.104	0.089	0.100	0.153
Unextractable ^{14}C		1.158	0.833	0.059	0.087	0.100	0.058	0.015	0.377
Total ^{14}C		1.484	1.071	0.336	0.302	0.204	0.147	0.115	0.530
Biosample wt (g)		2.529	14.905	0.559	0.117	6.079	19.101	0.936	

[a] Silica gel GF-254, benzene : *n*-hexane : acetic acid, 90:5:5 by volume.
[b] Internal organs, other than those specified, were combined and processed as an individual sample.
[c] Body totals were calculated using live body weight (45.479 g).
[d] Chloranil (tetrachloro-*p*-benzoquinone).
[e] Roman numerals = unknown compounds.
[f] Pentachlorophenol.
[g] Rf range denotes a streak on the TLC plate.

Table 67.—Relative affinities of 7 body-parts of the prairie vole[a] for $[^{14}C]$pentachlorophenol plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Liver	15.58	5.72
Carcass[b]	11.65	43.19
Skin	5.14	13.75
Brain	0.78	1.26
Uterine fat	0.44	2.12
Uterus	0.15	0.26
Remaining organs[c]	66.27	33.70
	100.01	100.00

[a] Vole from a soil-terrestrial model ecosystem treated with $[^{14}C]$pentachlorophenol.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

[c] The gastrointestinal tract + contents, kidneys + adrenals, heart, lungs, mammary glands, ventral central neck gland, parotid glands and small amounts of fat tissue were analyzed collectively; most (ca. 3/4) of the mass consisted of the gastrointestinal tract + contents.

Table 68.-Concentrations of [^{14}C]pentachlorophenol and degradation products in the water of a model ecosystem 7 days after flooding the ecosystem with water[a]

		Pentachlorophenol equivalents, ppm	
Compound	Rf[b]	Ether-extractable before hydrolysis	Ether-extractable after hydrolysis[c]
A[d]	.88	0.00051	0.00010
I[e]	.73	0.00005	
PCP[f]	.69	0.00069	0.00044
II	.54	0.00002	0.00001
III	.46	0.00001	<0.00001
IV	.36	0.00003	0.00001
V	.34		0.00001
VI	.31		0.00002
VII	.22		0.00002
VIII	.19		0.00002
IX	.16		0.00001
X	.12		0.00003
XI	.05		0.00004
XII	.04	0.00004	0.00007
XIII	.00	0.00004	0.00011
Extractable ^{14}C		0.00139	0.00089
Unextractable ^{14}C		0.00695	0.00296
Total extractable ^{14}C		0.00228	
Unextractable ^{14}C after hydrolysis		0.00296	
^{14}C loss during hydrolysis		0.00324	
Initial ^{14}C in water		0.00848	
Sample volume (1)		1.000	

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[a] Ecosystem was flooded with water 20 days after application of [^{14}C]pentachlorophenol to the soil.

[b] Silica gel GF-254, benzene : *n*-hexane : acetic acid, 90:5:5 by volume.

[c] The "unextractable" of the preceding column was adjusted to 0.012 N HCl and maintained at 55-56°C for 18-24 hours.

[d] Chloranil (tetrachloro-*p*-benzoquinone).

[e] Roman numerals = unknown compounds.

[f] Pentachlorophenol.

Table 69.-Concentrations of $[^{14}C]$pentachlorophenol and degradation products in aquatic organisms in a model ecosystem flooded with water[a]

Compound	Rf[c]	Pentachlorophenol equivalents, ppm[b] Gambusia[d] (fish)	Pentachlorophenol equivalents, ppm[b] Physa[e] (snail)
A[f]	.92	0.082	0.041
PCP[g]	.65	0.779	0.046
I[h]	.64		0.006
II	.52	0.161	0.186
III	.40	0.021	0.017
IV	.37		0.024
V	.16		0.029
VI	.07	0.010	0.035
VII	.04	0.016	0.113
VIII	.00	0.055	0.353
Extractable ^{14}C		1.124	0.850
Unextractable ^{14}C		0.636	1.665
Total ^{14}C		1.760	2.515
Average bio-sample wt (g)		0.310	0.016

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[a] Ecosystem was flooded with water 20 days after application of $[^{14}C]$pentachlorophenol to the soil.

[b] Average of triplicate determinations for fish; single determination for snails.

[c] Silica gel GF-254, benzene : *n*-hexane : acetic acid, 90:5:5 by volume.

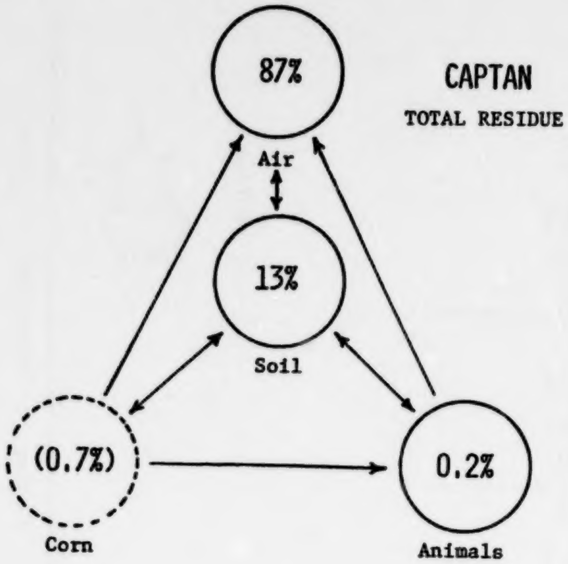
[d] Fish were added 4 days after flooding the ecosystem, removed 3 days later, and processed individually.

[e] Snails were added on the day of flooding; 15 snails were removed 7 days later and processed as a single batch; batch weight = 0.243 g.

[f] Chloranil (tetrachloro-*p*-benzoquinone).

[g] Pentachlorophenol.

[h] Roman numerals = unknown compounds.



Calculation of the above estimates:

Ecosystem component	Total maximum mass, g: (No.)	$\overline{X}$ mass	= total	Mean concentration, μg/g	Total residue, μg: (mass)(conc.)	Total residue as a % of applied dose (5000 μg)
Earthworms	(8)	3.37	= 27.0	0.181	4.88	0.1
Slugs	(3)	5.20	= 15.6	0.069	1.08	<0.1
Pillbugs	(13)	0.0336	= 0.437	0.470	0.205	<0.1
Caterpillars	(8)	0.722	= 5.78	0.299	1.73	<0.1
Vole	(1)	24.54	= 24.54	0.119	2.93	0.1
Animal total (I)			73.4		10.8	0.2
Corn[a/]	(27)	3.39	= 91.5	0.396	36.2	0.7
Soil (II)	(1)	3842	= 3842	0.165	634	12.7
Air				[5000 μg-(I+II)] =	4355	87.1

[a/] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the system.

Fig. 49.-Terminal environmental distribution of $[^{14}C]$captan plus metabolites in a soil-terrestrial model ecosystem.

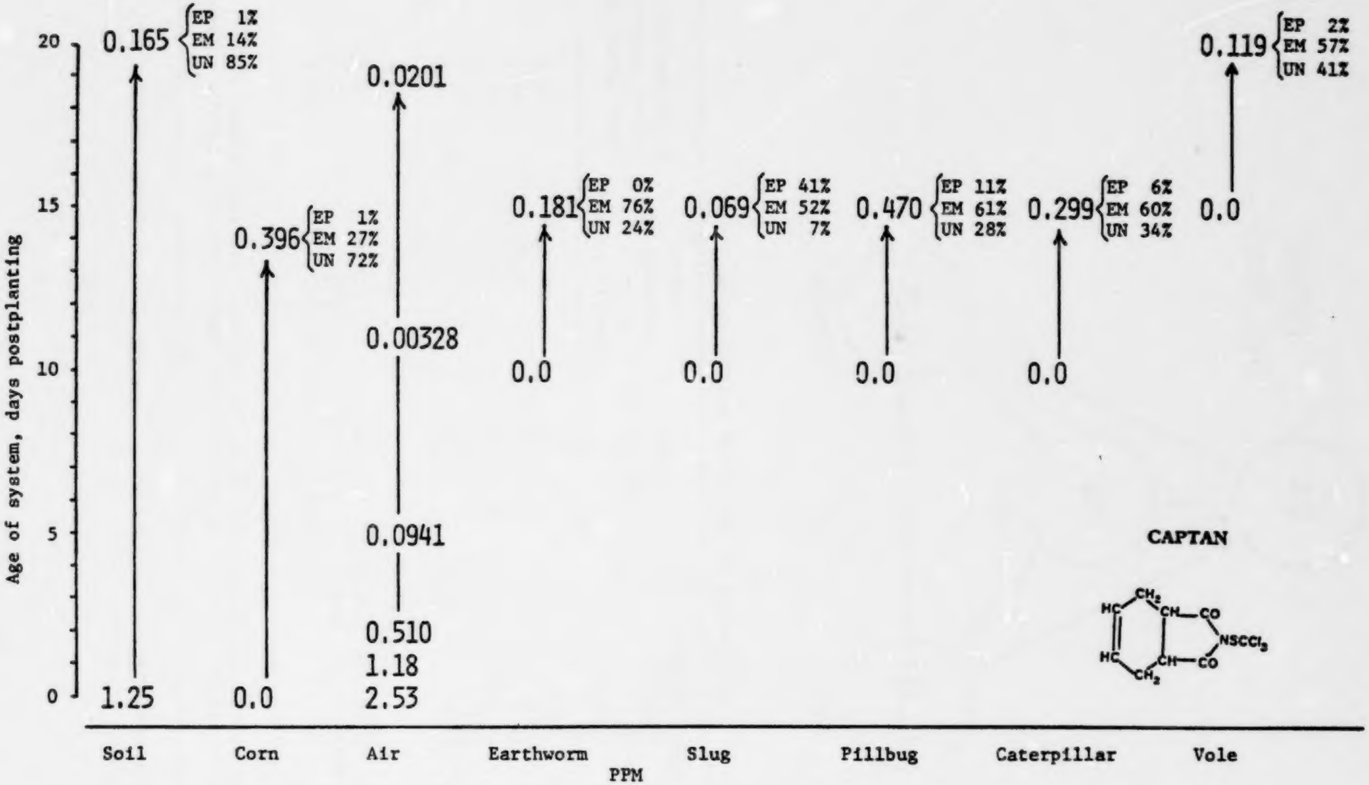


Fig. 50.—Summary of the fate of $[^{14}C]$captan in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as captan equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the soil was treated with captan at one lb AI/acre. On day 10 the invertebrates were added. On day 15, the vole was added.

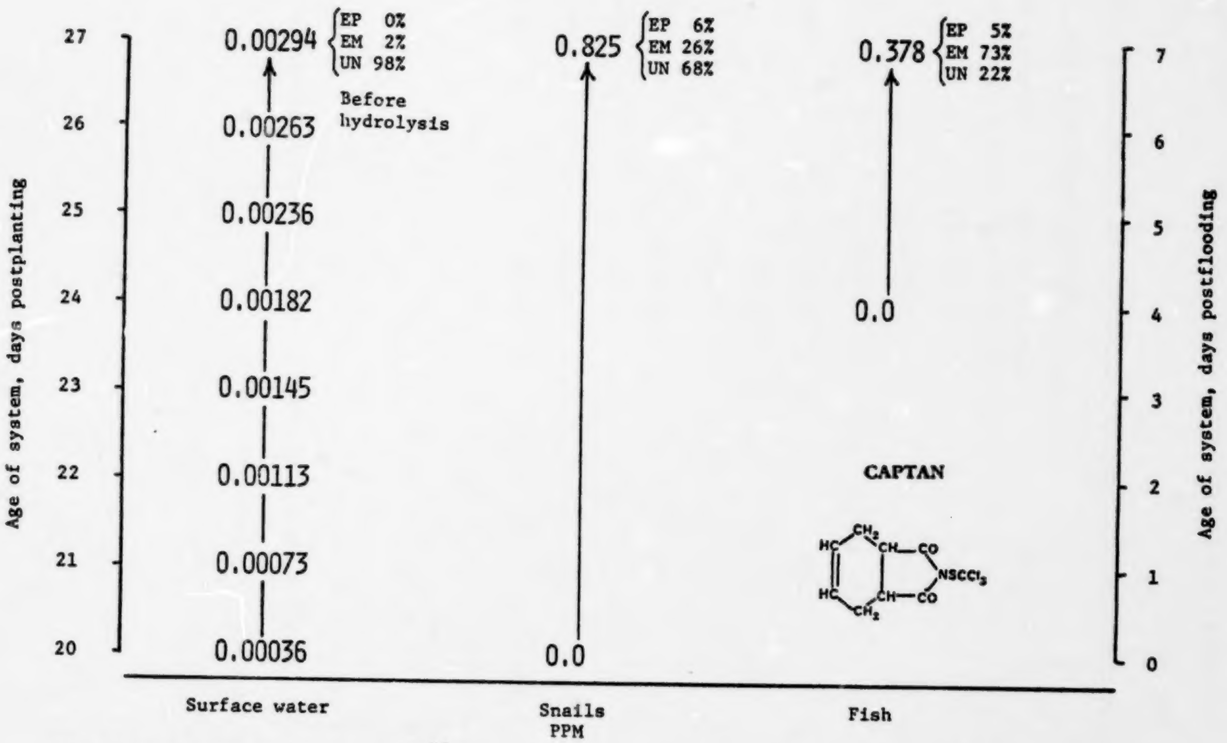


Fig. 51.—Summary of the fate of [^{14}C]captan in the aquatic phase; an extension of a soil-terrestrial model ecosystem (see Fig. 50). The barren terrestrial phase was flooded 20 days postplanting and snails, Daphnia, and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as captan equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 70.-Concentrations of $[^{14}C]$captan and degradation products in the soil of a model ecosystem 20 days after application of $[^{14}C]$captan to the soil

		Captan equivalents, ppm	
Compound	Rf[a]	Acetone extract	Methanol extract[b]
I[c]	.98	0.0008	
II	.89	0.0038	
III	.52-.81[d]	0.0025	
Captan	.51	0.0017	0.0001
IV	.18-.38	0.0011	
V	.15	0.0006	
VI	.06	0.0020	0.0001
VII	.04		0.0002
VIII	.00	0.0092	0.0029
Extractable ^{14}C		0.0217	0.0033
Unextractable ^{14}C		0.1397	
Total ^{14}C		0.1647	
Sample wt (g)		100.0000	

[a] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

[b] Methanol extract is from the sample previously extracted with acetone.

[c] Roman numerals = unknown compounds.

[d] Rf range denotes streak on TLC plate.

Table 71.-Concentrations of $[^{14}C]$captan and degradation products in corn[a/] after a 14-day exposure in a model ecosystem

Compound	Rf[c/]	Captan equivalents, ppm[b/] Root	Shoot	Entire plant
I[d/]	0.97	0.002	0.006	0.005
II	0.89	0.001	0.010	0.007
III	0.83	0.001		<0.001
IV	0.72		0.007	0.005
Captan	0.51	0.001	0.005	0.004
V	0.34-0.54[e/]		0.004	0.003
VI	0.32		0.001	0.001
VII	0.29		0.002	0.001
VIII	0.24		0.002	0.001
IX	0.13	0.002	0.011	0.008
X	0.06	0.001	0.018	0.013
XI	0.00	0.065	0.064	0.064
Extractable ^{14}C		0.073	0.130	0.112
Unextractable ^{14}C		0.294	0.280	0.284
Total ^{14}C		0.367	0.410	0.396
Average bio-sample wt (g)		0.672	1.491	2.163

[a/] $[^{14}C]$Captan was applied to the soil beneath each seed.

[b/] Average of triplicate determinations.

[c/] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

[d/] Roman numerals = unknown compounds.

[e/] Rf range denotes streak on TLC plate.

Table 72.-Concentrations of $[^{14}C]$captan and degradation products in invertebrates after a 5-day exposure in a model ecosystem

Compound	Rf[b]	Captan equivalents, ppm[a]			
		Armadillidium[c] (pillbug)	Estigmene (caterpillar)	Limax (slug)	Lumbricus (worm)
I[d]	.95	0.119	0.086		
II	.30-.74[e]				0.033
III	.70		0.014		
Captan	.49	0.053	0.019	0.028	
IV	.30			0.005	
V	.05-.30				0.015
VI	.05		0.013	0.004	
VII	.00	0.167	0.066	0.027	0.089
Extractable ^{14}C		0.339	0.198	0.064	0.137
Unextractable ^{14}C		0.131	0.101	0.005	0.044
Total ^{14}C		0.470	0.299	0.069	0.181
Average bio-sample wt (g)		0.034	0.722	5.204	3.366

[a] Average of duplicate determinations for caterpillars and worms; single determination for pillbugs and slug.

[b] Silica gel GF-254, diethyl ether : *n*-hexane, 7:3 by volume.

[c] Three pillbugs were processed together; batch weight = 0.101 g.

[d] Roman numerals = unknown compounds.

[e] Rf range denotes streak on TLC plate.

Table 73.-Concentrations of [^{14}C]captan and degradation products in the prairie vole after a 5-day exposure in a model ecosystem

Compound	Rf[a]	Captan equivalents, ppm							
		Uterus	Brain	Liver	Remaining organs[b]	Skin	Uterine fat	Carcass	Body totals[c]
I[d]	.89					0.029		0.007	0.007
II	.80	0.326	0.228	0.124		0.044		0.021	0.027
III	.71		0.018		0.033			0.010	0.014
Captan	.46			0.022		0.002	0.042	0.001	0.002
IV	.05		0.013	0.006		0.001		<0.001	0.001
V	.00	0.040	0.001	0.051	0.056	0.002	0.062	0.001	0.019
Extractable ^{14}C		0.366	0.260	0.203	0.089	0.078	0.104	0.040	0.070
Unextractable ^{14}C		0.076	0.019	0.065	0.129	0.046	0.020	0.007	0.049
Total ^{14}C		0.442	0.279	0.268	0.218	0.124	0.124	0.047	0.119
Biosample wt (g)		0.019	0.473	1.234	6.790	3.092	0.093	12.266	

[a] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

[b] Internal organs, other than those specified, were combined and processed as an individual sample.

[c] Body totals were calculated using live body weight (24.541 g).

[d] Roman numerals = unknown compounds.

Table 74.—Relative affinities of 7 body-parts of the prairie vole[a] for $[^{14}C]$captan plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-part (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass[b]	19.71	51.18
Skin	13.09	12.90
Liver	11.31	5.15
Brain	4.51	1.97
Uterine fat	0.41	0.39
Uterus	0.27	0.08
Remaining organs[c]	50.70	28.33
	100.00	100.00

[a] Vole from a soil-terrestrial model ecosystem treated with $[^{14}C]$captan.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

[c] The gastrointestinal tract + contents, kidneys + adrenals, heart, lungs, mammary glands, ventral central neck gland, parotid glands and small amounts of fat tissue were analyzed collectively; most (ca. 3/4) of the mass consisted of the gastrointestinal tract + contents.

Table 75.-Concentrations of [^{14}C]captan and degradation products in the water of a model ecosystem 7 days after flooding the ecosystem with water[a]

		Captan equivalents, ppm	
Compound	Rf[b]	Chloroform-extractable before hydrolysis	Chloroform-extractable after hydrolysis[c]
I[d]	.98	0.000002	
II	.79	0.000004	
III	.58	0.000003	
Captan	.55	0.000003	0.000003
IV	.25	0.000006	
V	.18		0.000012
VI	.13		0.000014
VII	.08		0.000019
VIII	.02	0.000008	0.000004
IX	.00	0.000023	0.000018
Extractable ^{14}C		0.000049	0.000070
Unextractable ^{14}C		0.002555	0.001143
Total extractable ^{14}C		0.000119	
Unextractable ^{14}C after hydrolysis		0.001143	
^{14}C loss during hydrolysis		0.001682	
Initial ^{14}C in water		0.002944	
Sample volume (l)		1.000	

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[a] Ecosystem was flooded with water 20 days after application of [^{14}C]captan to the soil.

[b] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

[c] The "unextractable" of the preceding column was adjusted to 0.012 N HCl and maintained at 55-56°C for 18-24 hours.

[d] Roman numerals = unknown compounds.

Table 76.-Concentrations of $[^{14}C]$captan and degradation products in aquatic organisms in a model ecosystem flooded with water[a]

		Captan equivalents, ppm[b]	
Compound	Rf[c]	Gambusia[d] (fish)	Physa[e] (snail)
I[f]	.98	0.215	0.026
II	.97		0.018
Captan	.57	0.021	0.048
III	.27		0.032
IV	.05	0.004	0.039
V	.00	0.056	0.104
Extractable ^{14}C		0.296	0.267
Unextractable ^{14}C		0.082	0.558
Total ^{14}C		0.378	0.825
Average bio-sample wt (g)		0.243	0.016

[a] Ecosystem was flooded with water 20 days after application of $[^{14}C]$captan to the soil.

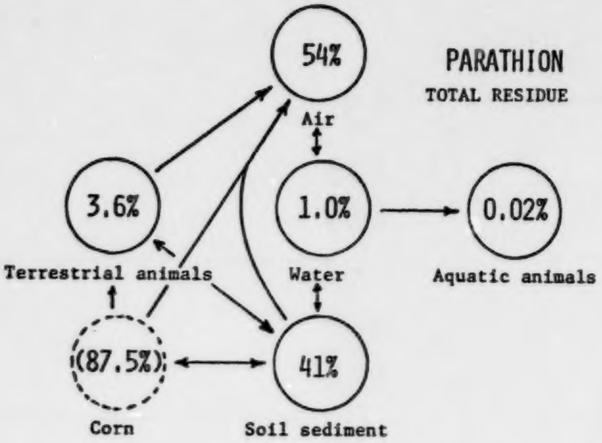
[b] Average of triplicate determinations for fish; single determination for snails.

[c] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

[d] Fish were added 4 days after flooding the ecosystem, removed 3 days later, and processed individually.

[e] Snails were added on the day of flooding; 15 snails were removed 7 days later and processed as a single batch; batch weight = 0.238 g.

[f] Roman numerals = unknown compounds.



Calculation of the above estimates:

Ecosystem component	Total maximum mass, g:			Mean concentration, μg/g	Total residue, μg:	Total residue as a % of applied dose (5000 μg)
	(No.)	$\overline{X}$ mass =	total		(mass)(conc.)	
Earthworms	(8)	4.29 =	34.3	1.29	44.3	0.9
Slugs	(5)	7.58 =	37.9	2.31	87.5	1.8
Pillbugs	(13)	0.032 =	0.416	9.71	4.04	0.1
Caterpillars	(8)	0.277 =	2.22	13.5	30.0	0.6
Vole	(1)	32.0 =	32.0	0.304	9.73	0.2
Terrestrial animal[a/] total (I)			107		176	3.6
Corn[b/]	(30)	3.39 =	102	42.9	4376	87.5
Snails	(50)	0.0080 =	0.400	1.35	0.540	0.011
Fish	(3)	0.392 =	1.18	0.223	0.263	0.005
Aquatic animal total (II)			1.58		0.803	0.016
Surface water (III)	(1)	7000 =	7000	0.00741	51.9	1.0
Soil sediment[c/] (IV)	(1)	3272 =	3272	0.630	2061	41.2
Air			[5000 μg-(I+II+III+IV)] =		2710	54.2

a/ The terrestrial animals (and their residues) were removed from the system at the termination of the terrestrial phase.

b/ Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the terrestrial phase, and its residue is distributed among animals, air, and soil.

c/ The direct interaction of corn, air, and terrestrial animals with the soil occurred prior to flooding the system.

Fig. 52.-Terminal environmental distribution of [^{14}C]parathion plus metabolites in a soil-terrestrial model ecosystem.

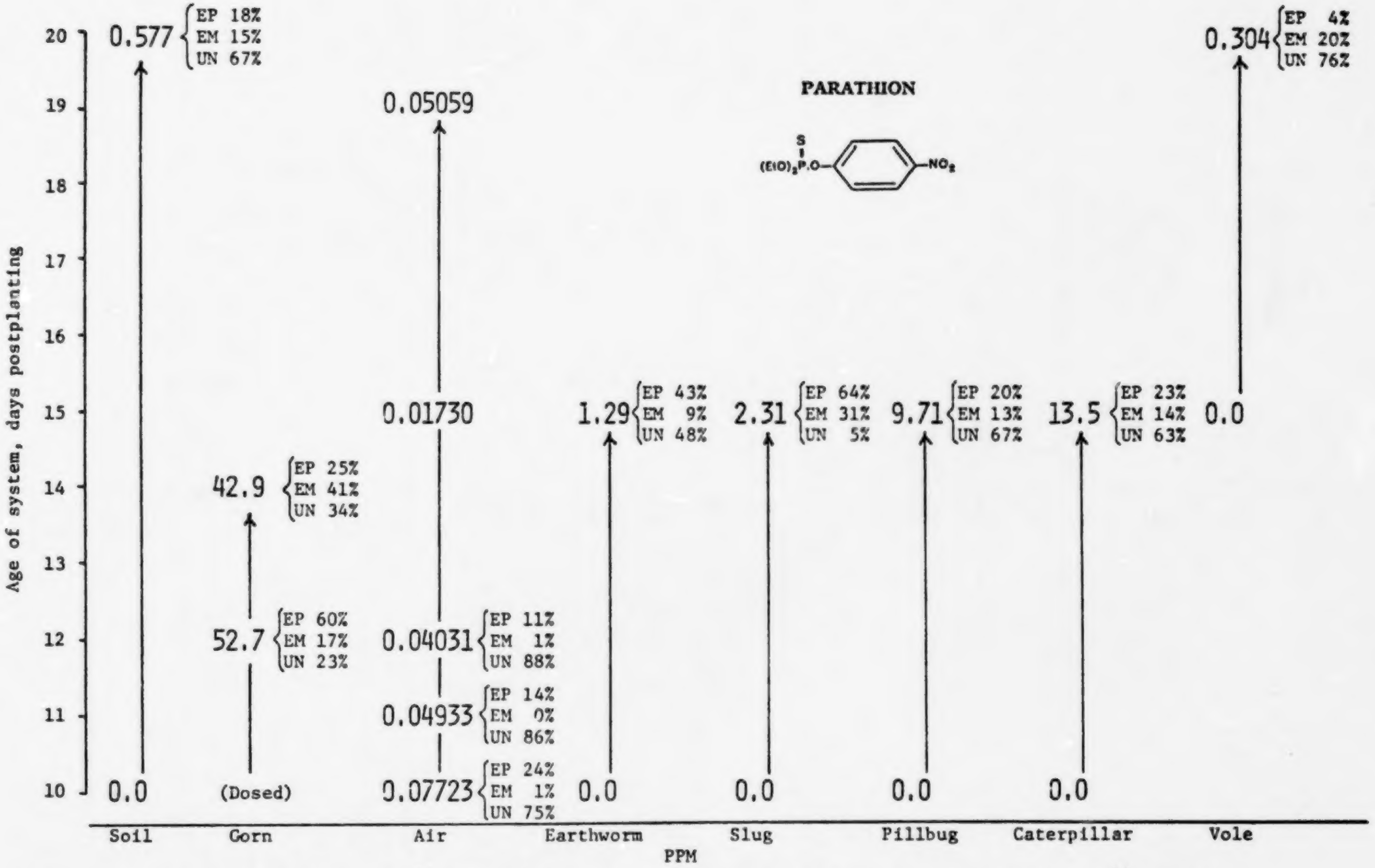


Fig. 53.—Summary of the fate of $[^{14}C]$parathion in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as parathion equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted. On day 10, the corn foliage was treated with parathion at one lb AI/acre, and the invertebrates were added. On day 15 the vole was added.

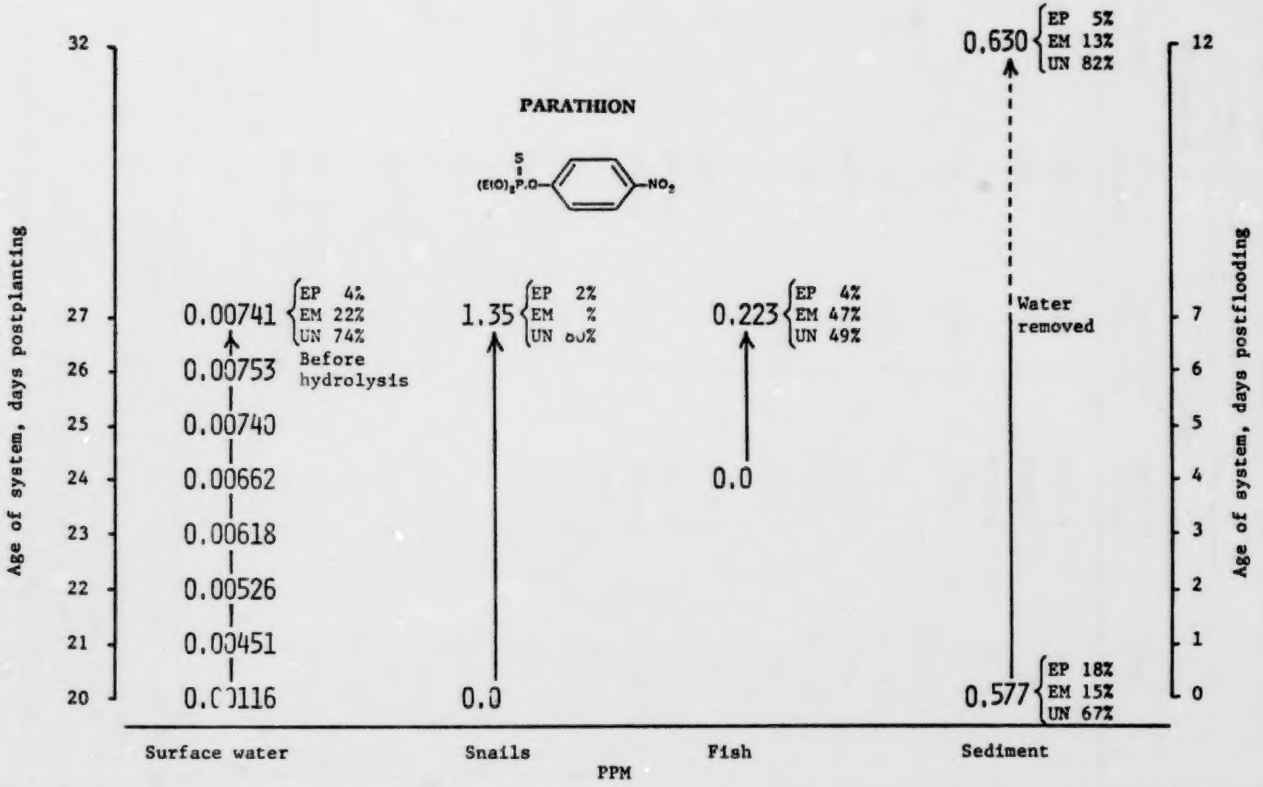


Fig. 54.—Summary of the fate of [^{14}C]parathion in the aquatic phase; an extension of a soil-terrestrial model ecosystem (see Fig. 53). The barren terrestrial phase was flooded 20 days postplanting and snails, Daphnia and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as parathion equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 77.-Concentrations of [^{14}C]parathion and degradation products in the soil and sediment of a model ecosystem

		Parathion equivalents, ppm			
		Soil[a]		Sediment[b]	
Compound	Rf[c]	Acetone extract	Methanol extract[d]	Acetone extract	Methanol extract
Parathion	.96	0.0825	0.0216	0.0286	0.0008
I[e]	.78-.93[f]	0.0037		0.0035	
II	.79	0.0009			
III	.69	0.0072	0.0020	0.0025	
IV	.20-.68				0.0013
V	.55-.66		0.0005	0.0007	
VI	.58	0.0008		0.0004	
VII	.45-.52	0.0008		0.0009	
VIII	.52	0.0005	0.0002		
IX	.20-.47		0.0012		
X	.43	0.0008		0.0021	
XI	.37	0.0010		0.0009	
XII	.18-.31	0.0026		0.0037	
XIII	.30	0.0037			
XIV	.17	0.0052	0.0010	0.0040	0.0017
XV	.13	0.0147	0.0033	0.0173	0.0048
XVI	.09-.12		0.0004		
XVII	.04-.08			0.0039	
XVIII	.07	0.0025	0.0014		0.0023
XIX	.04	0.0044		0.0051	
XX	.01-.04		0.0006		
XXI	.00	0.0244	0.0047	0.0219	0.0052
Extractable ^{14}C		0.1557	0.0369	0.0955	0.0161
Unextractable ^{14}C		0.3839		0.5179	
Total ^{14}C		0.5765		0.6295	
Sample wt (g)		100.0000		100.0000	

[a] Soil samples were taken 10 days after crop treatment.

[b] Sediment samples were taken 22 days after crop treatment, 12 days after flooding the ecosystem with water.

[c] Silica gel GF-254, diethyl ether : _n_-hexane, 7:3 by volume.

[d] Methanol extract is from the sample previously extracted with acetone.

[e] Roman numerals = unknown compounds.

[f] Rf range denotes a streak on the TLC plate.

Table 78.-Concentrations of $[^{14}C]$parathion and degradation products in corn[a/] grown in a model ecosystem

		Parathion equivalents, ppm[b/]					
		Day 12			Day 14		
Compound	Rf[c/]	Root	Shoot	Entire plant	Root	Shoot	Entire plant
Parathion	.94	0.183	49.305	31.608	0.168	15.185	10.853
I[d/]	.91	0.028		0.012			
II	.60	0.009		0.003	0.012		0.004
III	.52		1.724	1.161		2.898	1.931
IV	.41-.50[e/]		0.101	0.072			
V	.26-.45		0.597	0.379		1.125	0.744
VI	.35		0.045	0.033			
VII	.25	0.069	0.306	0.215	0.004	0.314	0.197
VIII	.11-.20	0.002		0.001	0.007	0.068	0.054
IX	.17	0.003		0.001	0.003		0.001
X	.14	0.002	0.527	0.371	0.001	0.202	0.141
XI	.09	0.008	0.260	0.164	0.104	0.307	0.231
XII	.05	0.005	0.361	0.223	0.015	0.622	0.425
XIII	.00	0.155	9.054	6.174	0.325	20.526	13.672
Extractable ^{14}C		0.464	62.280	40.417	0.639	41.247	28.253
Unextractable ^{14}C		0.598	17.923	12.283	1.071	21.513	14.685
Total ^{14}C		1.062	80.203	52.700	1.710	62.760	42.938
Average biosample wt (g)		0.557	1.196	1.753	0.693	1.322	2.015

[a/] $[^{14}C]$Parathion was applied to the corn leaves 10 days after planting the seeds; plants were harvested on indicated post-planting days.

[b/] Average of triplicate determinations.

[c/] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

[d/] Roman numerals = unknown compounds.

[e/] Rf range denotes a streak on the TLC plate.

Table 79.—Concentrations of [^{14}C]parathion and degradation products in the air of a model ecosystem 0, 1, and 2 days after applying the [^{14}C]parathion to the foliage.

Compounds	R_f[a]	Parathion equivalents, ppm					
		Day 0		Day 1		Day 2	
		Hexane-extractable from trap 1[b]	Hexane-extractable from trap 2[c]	Hexane-extractable from trap 1	Hexane-extractable from trap 2	Hexane-extractable from trap 1	Hexane-extractable from trap 2
Parathion	.94	0.01838		0.00679		0.00448	
I[d]	.33	0.00003				0.00005	
II	.02-.33[e]	0.00008					
III	.03-.32					0.00005	
IV	.04-.23			0.00005			
V	.03			0.00004			
VI	.00	0.00031		0.00002		0.00012	
Extractable ^{14}C		0.01880	0.00054	0.00690	0.00018	0.00470	0.00003
Unextractable ^{14}C		0.05226	0.00115	0.03866	0.00109	0.03306	0.00069
Sum traps 1 & 2							
Pre-extraction ^{14}C		0.07723		0.04933		0.04031	
Extractable ^{14}C		0.01934		0.00708		0.00473	
Unextractable ^{14}C		0.05341		0.03975		0.03375	
Extraction losses		0.00448		0.00250		0.00183	
Air sample wt. (g)[f]		108.00		108.00		108.00	

[a] Silica gel GF-254, diethyl ether : hexane, 7:3 by volume.

[b] n-Hexane extract of trapping solvent (ethanolamine:2-methoxyethanol, 1:2 by volume) in trap 1, the trap connected directly to the ecosystem container.

[c] The n-hexane extract of the trapping solvent (ethanolamine : 2-methoxyethanol, 1:2 by volume) in trap 2 was not chromatographed; trap 2 was connected in series to trap 1.

[d] Roman numerals = unknown compounds.

[e] R_f range denotes a streak on TLC plate.

[f] Air was trapped for 3 hr during daylight at a flow rate of 10 ml/sec, and 1 L of air was assumed to weigh 1 g.

Table 80.—Concentrations of [^{14}C]parathion and degradation products in invertebrates after a 5-day exposure in a model ecosystem.

		Parathion equivalents, ppm[a]			
Compounds	R_f[b]	*Lumbricus* (worm)	*Limax* (slug)	*Armadillidium*[c] (pillbug)	*Estigmene*[d] (caterpillar)
Parathion	.88	0.556	1.472	1.969	3.188
I[e]	.56	0.048	0.452	0.759	1.238
II	.34		0.005		
III	.30		0.008		0.006
IV	.22				0.083
V	.18		0.003		0.027
VI	.12		0.016		
VII	.08	0.044	0.064	0.156	
VIII	.04				0.178
IX	.00	0.027	0.158	0.359	0.338
Extractable ^{14}C		0.675	2.178	3.243	5.058
Unextractable ^{14}C		0.617	0.128	6.463	8.468
Total ^{14}C		1.292	2.306	9.706	13.526
Average bio-sample wt. (g)		4.286	7.578	0.032	0.277

[a] Average of duplicate determinations for worm and caterpillar; single determination for slug and pillbug.

[b] Silica gel GF-254, diethyl ether : *n*-hexane, 7:3 by volume.

[c] Two pillbugs were analyzed together as the extract; both were dead when sampled.

[d] One determination was based on a dead caterpillar.

[e] Roman numerals = unknown compounds.

Table 81.-Concentrations of [^{14}C]parathion and degradation products in the prairie vole after a 5-day exposure[a] in a model ecosystem

		Parathion equivalents, ppm							
Compound	Rf[b]	Remaining organs[c]	Liver	Skin	Uterus and ovaries[d]	Carcass	Uterine fat[d]	Brain	Body totals[e]
Parathion	.87			0.028		0.016			0.013
I[f]	.63	0.078							0.017
II	.15	0.023	0.006						0.006
III	.04	0.037		0.001					0.008
IV	.00	0.118	0.015	0.001		0.001		0.010	0.028
Extractable ^{14}C		0.256	0.021	0.030	0.037	0.017	0.035	0.010	0.073
Unextractable ^{14}C		0.837	0.128	0.101	0.028	0.036	0.015	0.018	0.231
Total ^{14}C		1.093	0.149	0.131	0.065	0.053	0.050	0.028	0.304
Biosample wt (g)		7.085	2.162	5.948	0.164	15.824	0.173	0.639	31.995

[a] [^{14}C]Parathion was applied to the corn foliage 5 days before the vole was added to the ecosystem.

[b] Silica gel GF-254, diethyl ether : *n*-hexane, 7:3 by volume.

[c] Internal organs, other than those specified, were combined and analyzed as one sample.

[d] Autoradiographic analysis of extracts of these organs was unsuccessful because of low radioactive content.

[e] Body totals were calculated using the sum of the weights of dissected organs; live body weight = 31.596 g.

[f] Roman numerals = unknown compounds.

Table 82.—Relative affinities of 7 body-parts of the prairie vole[a] for $[^{14}C]$parathion plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass[b]	8.71	49.46
Skin	8.00	18.59
Liver	3.31	6.76
Brain	0.18	2.00
Uterus + ovaries	0.10	0.51
Uterine fat	0.09	0.54
Remaining organs[c]	79.61	22.14
	100.00	100.00

[a] Vole from a soil-terrestrial model ecosystem treated with $[^{14}C]$parathion.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

[c] The gastrointestinal tract + contents, kidneys + adrenals, heart, lungs, mammary glands, ventral central neck gland, parotid glands and small amounts of fat tissue were analyzed collectively; most (ca. 3/4) of the mass consisted of the gastrointestinal tract + contents.

Table 83.-Concentrations of [^{14}C]parathion and degradation products in the water of a model ecosystem 7 days after flooding the ecosystem with water[a]

		Parathion equivalents, ppm	
Compound	Rf[b]	Ether-extractable before hydrolysis	Ether-extractable after hydrolysis[c]
Parathion	.90	0.00029	0.00013
I[d]	.73-.84[e]	0.00006	
II	.68	0.00013	0.00009
III	.39-.66	0.00007	
IV	.59		0.00003
V	.10-.46		0.00017
VI	.35	0.00004	
VII	.29	0.00003	
VIII	.24	0.00002	
IX	.17-.22	0.00003	
X	.16	0.00012	
XI	.11	0.00070	
XII	.07	0.00012	0.00013
XIII	.03		0.00010
XIV	.00	0.00032	0.00031
Extractable ^{14}C		0.00193	0.00096
Unextractable ^{14}C		0.00545	0.00379
Total extractable ^{14}C		0.00289	
Unextractable ^{14}C after hydrolysis		0.00379	
^{14}C loss during hydrolysis		0.00073	
Initial ^{14}C in water		0.00741	
Sample volume (l)		1.000	

[a] Ecosystem was flooded with water 20 days after application of [^{14}C]parathion to the corn foliage.

[b] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

[c] The "unextractable" of the preceding column was adjusted to 0.012 N HCl and maintained at 55-56°C for 18-24 hours.

[d] Roman numerals = unknown compounds.

[e] Rf range denotes a streak on the TLC plate.

Table 84.—Concentrations of [^{14}C]parathion and degradation products in aquatic organisms from a model ecosystem flooded with water[a].

Compounds	R_f[c]	Parathion equivalents, ppm[b]	
		Gambusia[d] (fish)	Physa[e] (snail)
Parathion	.95	0.008	0.023
I[f]	.18-.90[g]		0.080
II	.72	0.029	
III	.14	0.016	
IV	.03-.12		0.039
V	.09	0.014	
VI	.00	0.047	0.132
Extractable ^{14}C		0.114	0.274
Unextractable ^{14}C		0.109	1.080
Total ^{14}C		0.223	1.354
Average biosample wt. (g)		0.392	0.0083

[a] Ecosystem was flooded with water 20 days after application of the [^{14}C]parathion to the foliage.

[b] Average of triplicate determinations for fish; single determination for snail.

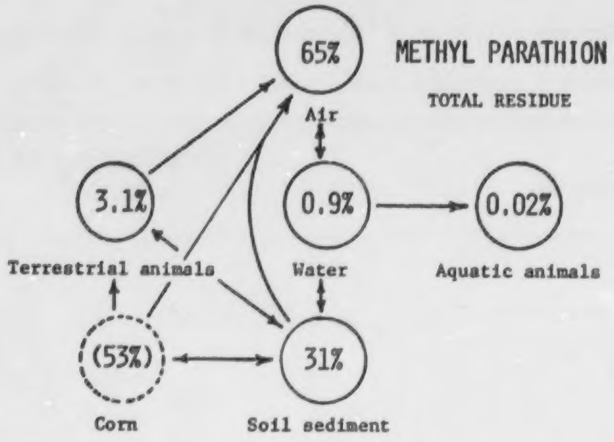
[c] Silica gel GF-254, diethyl ether : *n*-hexane, 7:3 by volume.

[d] Fish were added 4 days after flooding the ecosystem, removed 3 days later, and processed individually.

[e] Snails were added on the day of flooding, removed 7 days later, and processed in one batch of 15 snails; total batch weight = 0.124 g.

[f] Roman numerals = unknown compounds.

[g] R_f range denotes a streak on the TLC plate.



Calculation of the above estimates:

Ecosystem component	Total maximum mass, g: (No.)	$\overline{X}$ mass	= total	Mean concentration, µg/g	Total residue, µg: (mass)(conc.)	Total residue as a % of applied dose (5000 µg)
Earthworms	(8)	3.86	= 30.9	3.07	94.8	1.9
Slugs	(5)	5.59	= 28.0	0.955	26.7	0.5
Pillbugs	(13)	0.077	= 1.00	6.66	6.66	0.1
Caterpillars	(8)	0.930	= 7.44	2.36	17.6	0.4
Vole	(1)	20.1	= 20.1	0.532	10.7	0.2
Terrestrial animal[a] total (I)			87.4		156	3.1
Corn[b]	(32)	3.39	= 108	24.5	2658	53.2
Snails	(50)	0.013	= 0.650	1.19	0.774	0.015
Fish	(3)	0.329	= 0.987	0.236	0.233	0.005
Aquatic animal total (II)			1.64		1.01	0.020
Surface water (III)	(1)	7000	= 7000	0.00667	46.7	0.9
Soil sediment[c] (IV)	(1)	3435	= 3435	0.455	1563	31.3
Air			[5000 µg-(I+II+III+IV)]		= 3233	64.7

a/ The terrestrial animals (and their residues) were removed from the system at the termination of the terrestrial phase.

b/ Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the terrestrial phase, and its residue is distributed among animals, air, and soil.

c/ The direct interaction of corn, air, and terrestrial animals with the soil occurred prior to flooding the system.

Fig. 55.-Terminal environmental distribution of $[^{14}C]$methyl parathion plus metabolites in a soil-terrestrial model ecosystem.

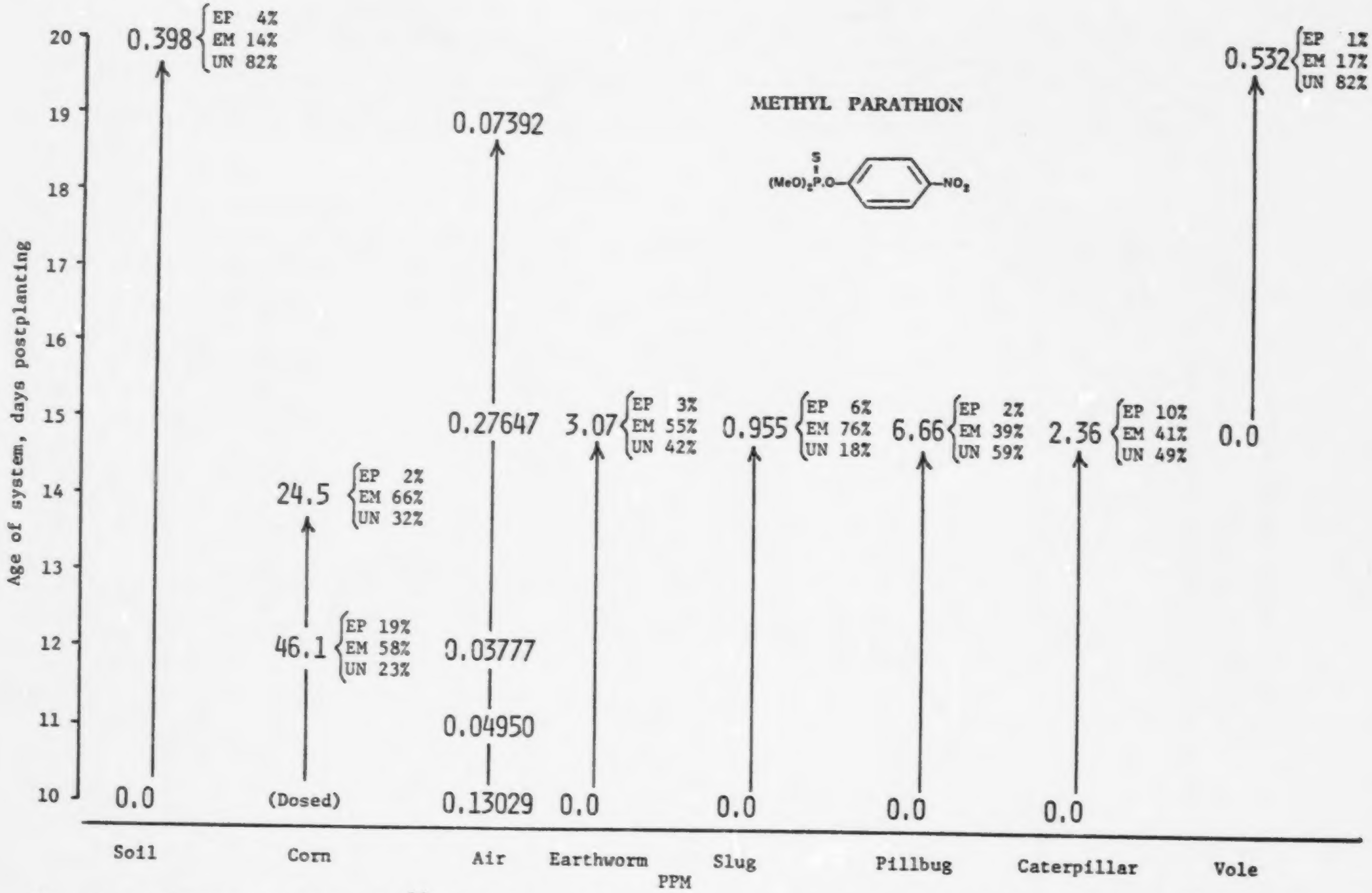


Fig. 56.—Summary of the fate of [^{14}C]methyl parathion in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as methyl parathion equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted. On day 10, the corn foliage was treated with methyl parathion at one lb AI/acre, and the invertebrates were added. On day 15 the vole was added.

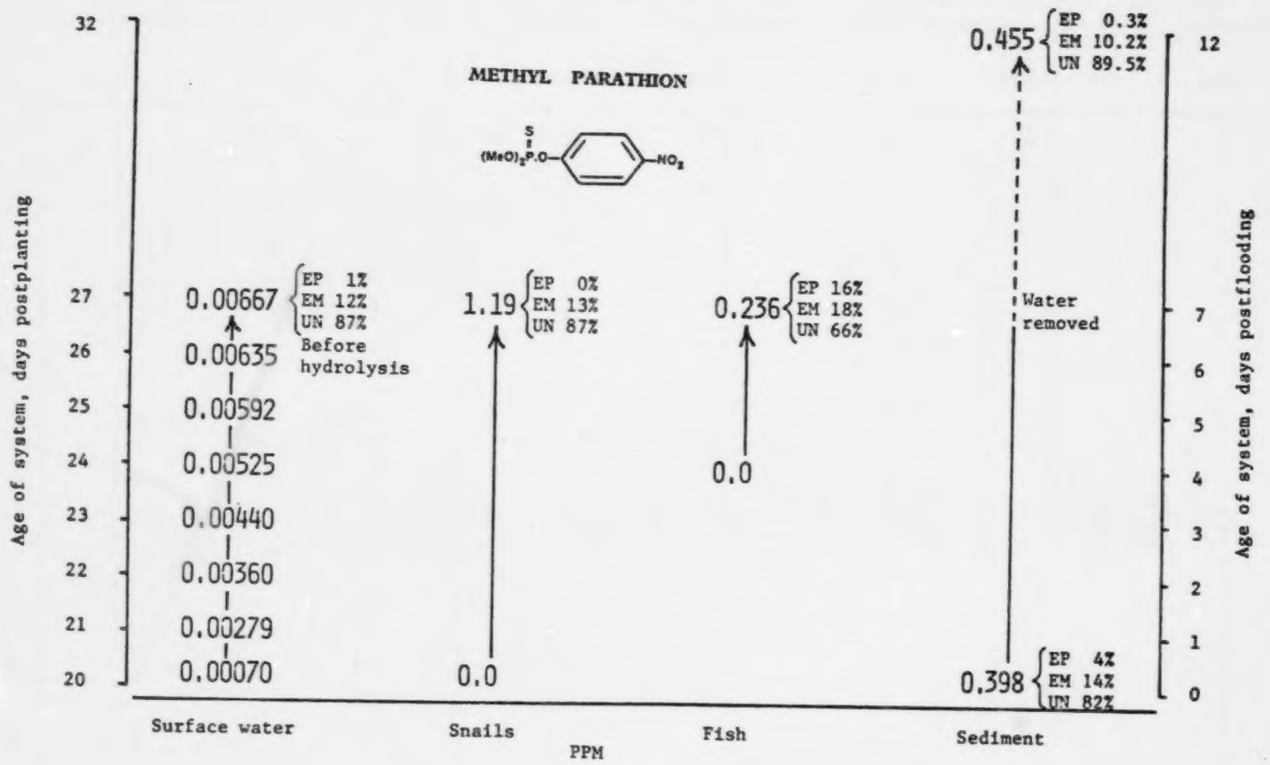


Fig. 57.—Summary of the fate of [^{14}C]methyl parathion in the aquatic phase; an extension of a soil-terrestrial model ecosystem (see Fig. 56). The barren terrestrial phase was flooded 20 days postplanting and snails, Daphnia, and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as methyl parathion equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 85.-Concentrations of [^{14}C]methyl parathion and degradation products in the soil and sediment of a model ecosystem

Compound	Rf[c]	Methyl parathion equivalents, ppm			
		Soil[a]		Sediment[b]	
		Acetone extract	Methanol extract[d]	Acetone extract	Methanol extract
I[e]	.98	0.0024	0.0004	0.0018	0.0006
Methyl parathion	.93	0.0133	0.0015	0.0011	0.0002
II	.88			0.0076	<0.0001
III	.76-.86[f]	0.0025		0.0020	
IV	.80		0.0001		
V	.70	0.0137	0.0039	0.0032	0.0005
VI	.58-.67		0.0002		
VII	.20-.67				0.0006
VIII	.48-.64	0.0014		0.0017	
IX	.45	0.0006		0.0004	
X	.28-.44	0.0012			
XI	.18-.42		0.0005	0.0021	
XII	.25	0.0008			
XIII	.16-.21	0.0009			
XIV	.19				0.0002
XV	.16		0.0003	0.0005	0.0002
XVI	.13	0.0019	0.0006	0.0009	0.0007
XVII	.08	0.0048	0.0007	0.0038	0.0016
XVIII	.03-.07			0.0043	
XIX	.03	0.0037	0.0006		
XX	.00	0.0127	0.0032	0.0118	0.0020
Extractable ^{14}C		0.0599	0.0120	0.0412	0.0066
Unextractable ^{14}C		0.3256		0.4069	
Total ^{14}C		0.3975		0.4547	
Sample wt (g)		100.0000		100.0000	

[a] Soil samples were taken 10 days after crop treatment.

[b] Sediment samples were taken 22 days after crop treatment, 12 days after flooding the ecosystem with water.

[c] Silica gel GF-254, diethyl ether : _n_-hexane, 7:3 by volume.

[d] The methanol extract is from the sample previously extracted with acetone.

[e] Roman numerals = unknown compounds.

[f] Rf range denotes a streak on the TLC plate.

Table 86.-Concentrations of [^{14}C]methyl parathion and degradation products in corn[a] grown in a model ecosystem

		Methyl parathion equivalents, ppm[b]					
		Day 12			Day 14		
Compound	Rf[c]	Root	Shoot	Entire plant	Root	Shoot	Entire plant
I[d]	.96	0.005		0.002			
Methyl parathion	.90	0.030	12.826	8.933	0.017	0.919	0.596
II	.70-.88[e]	0.004		0.001			
III	.84	0.014	0.047	0.031			
IV	.73		2.495	2.018		0.095	0.061
V	.67	0.076	10.549	7.251	0.075	8.505	5.486
VI	.37-.66	0.008		0.001			
VII	.47-.63		0.280	0.229			
VIII	.21-.62	0.008	0.826	0.521		0.348	0.223
IX	.44		0.031	0.025			
X	.36	0.023		0.008	0.027		0.010
XI	.22-.34	0.002	0.045	0.037			
XII	.25	0.004		0.002	0.003		0.001
XIII	.03-.24	0.006		0.002			
XIV	.22		0.055	0.038			
XV	.17	0.002	0.234	0.164	0.004	0.175	0.115
XVI	.04-.16	0.003		0.001			
XVII	.15		0.206	0.135	0.008	0.121	0.080
XVIII	.11		0.416	0.271		0.308	0.198
XIX	.08		0.216	0.172		0.097	0.061
XX	.04	0.003	0.950	0.651		0.463	0.295
XXI	.00	0.301	21.573	14.919	0.557	14.495	9.505
Extractable ^{14}C		0.489	50.749	35.412	0.691	25.526	16.631
Unextractable ^{14}C		0.480	15.244	10.661	0.397	12.029	7.869
Total ^{14}C		0.969	65.993	46.073	1.088	37.555	24.500
Average biosample wt (g)		0.525	1.268	1.793	0.595	1.074	1.669

[a] [^{14}C]Methyl parathion was applied to the corn leaves 10 days after planting the seeds; plants were harvested on indicated post-planting days.
[b] Average of triplicate determinations.
[c] Silica gel GF-254, diethyl ether : *n*-hexane, 7:3 by volume.
[d] Roman numerals = unknown compounds.
[e] Rf range denotes a streak on the TLC plate.

Table 87.—Concentrations of [^{14}C]methyl parathion and degradation products in the air of a model ecosystem one day after applying the [^{14}C]methyl parathion to the foliage.

	Methyl parathion equivalents, ppm		
Compounds	R_f[a]	Hexane-extractable from trap 1[b]	Hexane-extractable from trap 2[c]
Methyl parathion	.84	0.00012	
I[d]	.38	0.00001	
II	.00	0.00000	
Extractable ^{14}C		0.00013	0.00002
Unextractable ^{14}C		0.04624	0.00025
Sum traps 1 & 2			
Pre-extraction ^{14}C		0.04950	
Extractable ^{14}C		0.00015	
Unextractable ^{14}C		0.04649	
Extraction losses		0.00286	
Air sample wt. (g)[e]		108.00	

a/ Silica gel GF-254, diethyl ether : hexane, 7:3 by volume.

b/ n-Hexane extract of trapping solvent (ethanolamine : 2-methoxyethanol, 1:2 by volume) in trap 1, the trap connected directly to the ecosystem container.

c/ The n-hexane extract of the trapping solvent (ethanolamine : 2-methoxyethanol, 1:2 by volume) in trap 2 was not chromatographed; trap 2 was connected in series to trap 1.

d/ Roman numerals = unknown compounds.

e/ Air was trapped for 3 hr during daylight at a flow rate of 10 ml/sec, and 1 L of air was assumed to weigh 1 g.

Table 88.—Concentrations of $[^{14}C]$methyl parathion and degradation products in invertebrates after a 5-day exposure in a model ecosystem.

		Methyl parathion equivalents, ppm[a]			
Compounds	R_f[b]	*Lumbricus* (worm)	*Limax* (slug)	*Armadillidium*[c] (pillbug)	*Estigmene* (caterpillar)
I[d]	.97			0.029	0.169
Methyl parathion	.81	0.092	0.053	0.150	0.224
II	.66	0.020		0.093	
III	.60	0.415		1.653	
IV	.54		0.428		0.540
V	.20		0.005		
VI	.12	0.004	0.021		
VII	.08	0.011	0.080	0.064	
VIII	.04	0.074			
IX	.00	1.164	0.197	0.757	0.259
Extractable ^{14}C		1.780	0.784	2.746	1.192
Unextractable ^{14}C		1.291	0.171	3.911	1.164
Total ^{14}C		3.071	0.955	6.657	2.356
Average biosample wt. (g)		3.858	5.587	0.077	0.930

[a] Average of duplicate determinations for worm and caterpillar; single determination for slug and pillbug.

[b] Silica gel GF-254, diethyl ether : *n*-hexane, 7:3 by volume.

[c] Three pillbugs were analyzed together as the extract.

[d] Roman numerals = unknown compounds.

Table 89.-Concentrations of [^{14}C]methyl parathion and degradation products in the prairie vole after a 5-day exposure[a] in a model ecosystem

Compound	Rf[b]	Methyl parathion equivalents, ppm						
		Remaining organs[c]	Uterus and ovaries[d]	Liver	Skin	Carcass	Brain	Body totals[e]
I[f]	.93					0.006		0.003
Methyl parathion	,81				0.015	0.006		0.005
II	.25-.74[g]					0.003		0.001
III	.68	0.011		0.004				0.003
IV	.53	0.027						0.007
V	.39			0.002				<0.001
VI	.15-.39	0.027						0.007
VII	.22					0.001		0.001
VIII	.14	0.043		0.005	0.004	0.001		0.013
IX	.06	0.083						0.021
X	.00	0.122		0.009	0.006	0.003	0.012	0.035
Extractable ^{14}C		0.313	0.285	0.020	0.025	0.020	0.012	0.097
Unextractable ^{14}C		1.511	0.069	0.196	0.078	0.042	0.044	0.435
Total ^{14}C		1.824	0.354	0.216	0.103	0.062	0.056	0.532
Biosample wt (g)		5.206	0.080	1.044	2.969	10.140	0.622	

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[a] [^{14}C]Methyl parathion was applied to the corn foliage 5 days before the vole was added to the ecosystem.

[b] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

[c] Internal organs, other than those specified, were combined and analyzed as one sample.

[d] The extract of these organs was not chromatographed.

[e] Body totals were calculated using live body weight (20.140 g).

[f] Roman numerals = unknown compounds.

[g] Rf range denotes a streak on the TLC plate.

Table 90.—Relative affinities of 6 body-parts of the prairie vole[a] for $[^{14}C]$methyl parathion plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-parts (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass[b]	5.81	50.55
Skin	2.88	14.80
Liver	2.11	5.20
Brain	0.33	3.10
Uterus + ovaries	0.26	0.40
Remaining organs[c]	88.61	25.95
	100.00	100.00

[a] Vole from a soil-terrestrial model ecosystem treated with $[^{14}C]$methyl parathion.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

[c] The gastrointestinal tract + contents, kidneys + adrenals, heart, lungs, mammary glands, ventral central neck gland, parotid glands and small amounts of fat tissue were analyzed collectively; most (ca. 3/4) of the mass consisted of the gastrointestinal tract + contents.

Table 91.-Concentrations of [^{14}C]methyl parathion and degradation products in the water of a model ecosystem 7 days after flooding the ecosystem with water[a]

Compound	Rf[b]	Methyl parathion equivalents, ppm	
		Ether-extractable before hydrolysis	Ether-extractable after hydrolysis[c]
Methyl parathion	.94	0.00009	0.00006
I[d]	.81	0.00002	
II	.72	0.00014	0.00004
III	.19-.71[e]	0.00010	
IV	.63		0.00001
V	.53-.61		0.00002
VI	.50		0.00003
VII	.34-.47		0.00003
VIII	.32		0.00001
IX	.18-.30		0.00003
X	.18		0.00003
XI	.14	0.00007	0.00006
XII	.12	0.00020	0.00002
XIII	.07	0.00003	0.00008
XIV	.03		0.00013
XV	.00	0.00025	0.00028
Extractable ^{14}C		0.00090	0.00083
Unextractable ^{14}C		0.00427	0.00326
Total extractable ^{14}C		0.00173	
Unextractable ^{14}C after hydrolysis		0.00326	
^{14}C loss during hydrolysis		0.00168	
Initial ^{14}C in water		0.00667	
Sample volume (l)		1.000	

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[a] Ecosystem was flooded with water 20 days after application of [^{14}C]methyl parathion to the corn foliage.

[b] Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

[c] The "unextractable" of the preceding column was adjusted to 0.012 N HCl and maintained at 55-56°C for 18-24 hours.

[d] Roman numerals = unknown compounds.

[e] Rf range denotes a streak on the TLC plate.

Table 92.—Concentrations of [^{14}C]methyl parathion and degradation products in aquatic organisms from a model ecosystem flooded with water[a].

Compounds	R_f[c]	Methyl parathion equivalents, ppm[b]	
		Gambusia[d] (fish)	Physa[e] (snail)
I[f]	.99		0.008
Methyl parathion	.89	0.038	
II	.24-.75[g]		0.052
III	.60	0.014	
IV	.20		0.008
V	.05-.16		0.010
VI	.05	0.011	0.005
VII	.00	0.017	0.072
Extractable ^{14}C		0.080	0.155
Unextractable ^{14}C		0.156	1.036
Total ^{14}C		0.236	1.191
Average biosample wt. (g)		0.329	0.013

a/ Ecosystem was flooded with water 20 days after application of the [^{14}C]methyl parathion to the foliage.

b/ Average of triplicate determinations for fish; single determination for snail.

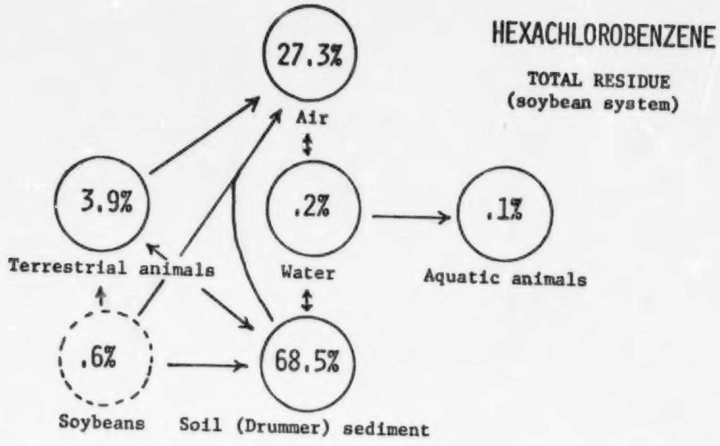
c/ Silica gel GF-254, diethyl ether : n-hexane, 7:3 by volume.

d/ Fish were added 4 days after flooding the ecosystem, removed 3 days later, and processed individually.

e/ Snails were added on the day of flooding, removed 7 days later, and processed in one batch of 15 snails; total batch weight = 0.192 g.

f/ Roman numerals = unknown compounds.

g/ R_f range denotes a streak on the TLC plate.


HEXACHLOROBENZENE
TOTAL RESIDUE
(soybean system)
27.3%
Air
3.9%
Terrestrial animals
.2%
Water
.1%
Aquatic animals
.6%
Soybeans
68.5%
Soil (Drummer) sediment

Calculations of the above estimates:

Ecosystem component	Total maximum mass, g:			Mean concentration, µg/g	Total residue, µg:	Total residue as a % of applied dose (5000 µg)
	(No.)	$\bar{X}$ mass =	total		(mass)(conc.)	
Earthworms	(10)	3.62 =	36.2	4.46	161	3.2
Slugs	(8)	6.76 =	54.1	.195	10.5	.2
Pillbugs	(20)	.0697 =	1.39	1.53	2.13	.04
Caterpillars	(10)	1.18 =	11.8	.656	7.74	.2
Vole	(1)	21.6 =	21.6	.695	15.0	.3
Terrestrial animal[a] total (I)			125		196	3.9
Soybeans[b]	(34)	.718 =	24.4	1.15	28.1	.6
Snails	(50)	.101 =	5.05	.801	4.05	.08
Fish	(3)	.168 =	.504	2.38	1.20	.02
Aquatic animal total (II)			5.55		5.25	.1
Surface water (III)	(1)	7000 =	7000	.00117	8.19	.2
Soil sediment[c] (IV)	(1)	4130 =	4130	.829	3424	68.5
Air					[5000 µg-(I+II+III+IV)] = 1367	27.3

a/ The terrestrial animals (and their residues) were removed from the system at the termination of the terrestrial phase.

b/ Proportion at 14 days postplanting; the soybeans, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the terrestrial phase, and its residue is distributed among animals, air, and soil.

c/ The direct interaction of soybeans, air, and terrestrial animals with the soil occurred prior to flooding the system.

Fig. 58.-Terminal environmental distribution of $[^{14}\mathrm{C}]$hexachlorobenzene plus metabolites in a soil-terrestrial model ecosystem.

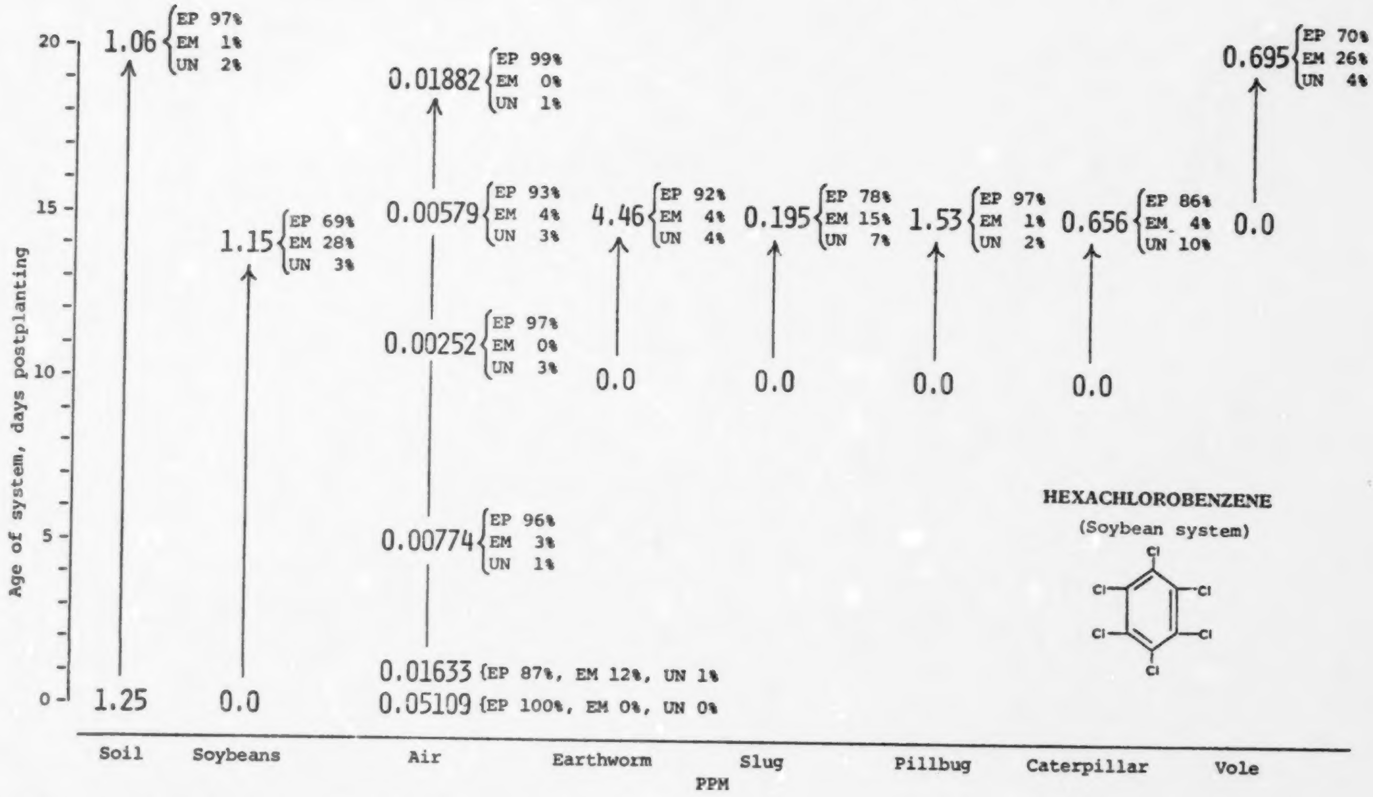


Fig. 59.—Summary of the fate of $[^{14}C]$hexachlorobenzene (soybean system) in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as hexachlorobenzene equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the soybean seeds were planted and the soil was treated with hexachlorobenzene at one lb AI/acre. On days 10 and 15, the invertebrates and the vole were added, respectively.

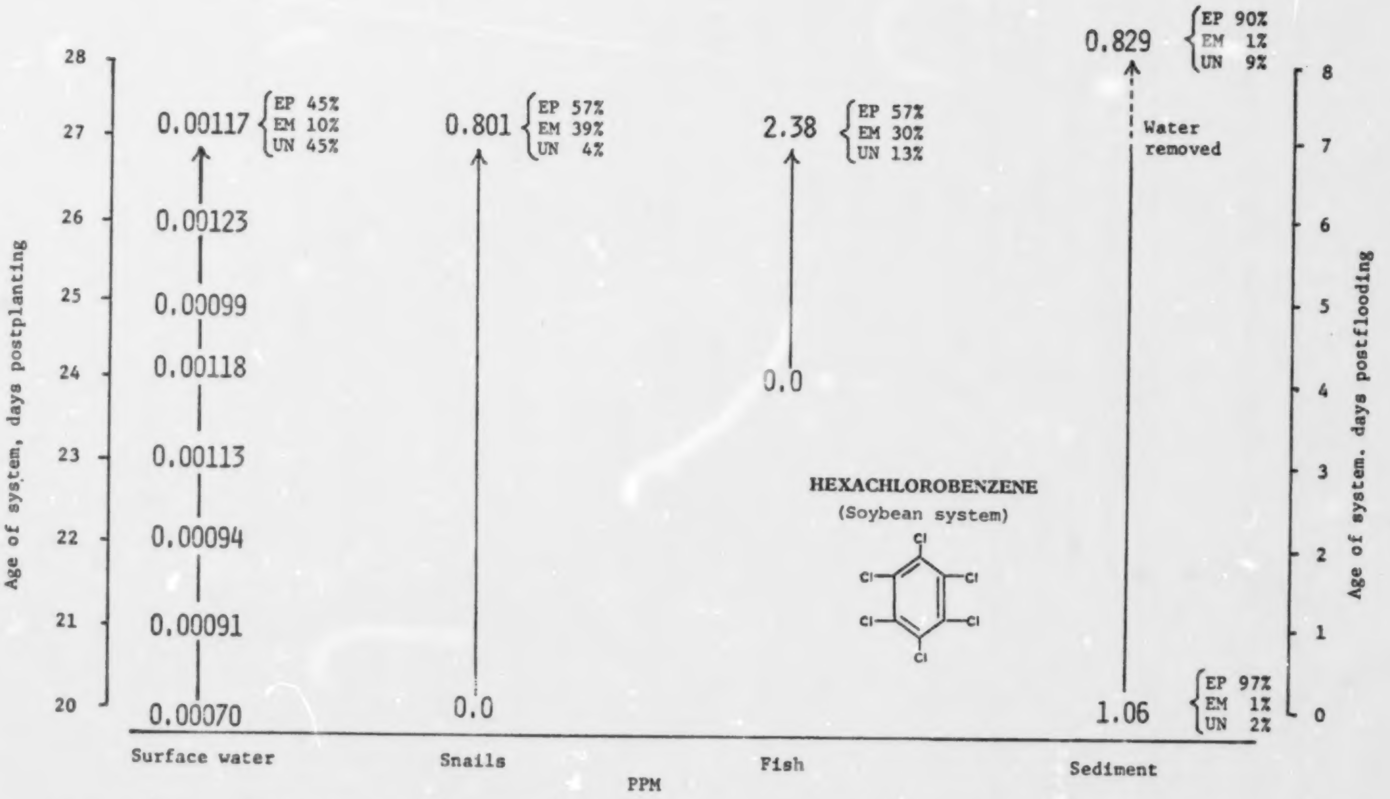


Fig. 60.—Summary of the fate of [^{14}C]hexachlorobenzene (soybean system) in the aquatic phase; an extension of a soil-terrestrial model ecosystem (see Fig.). The barren terrestrial phase was flooded 20 days postplanting, and snails, daphnia and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as hexachlorobenzene equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 93.—Concentrations of $[^{14}C]$hexachlorobenzene and degradation products in the soil and sediment of a model ecosystem in which soybeans were grown.

		Hexachlorobenzene equivalents, ppm			
		Soil[a]		Sediment[b]	
Compound	R_f[c]	Acetone extract	Methanol extract[d]	Acetone extract	Methanol extract
HCB[e]	.94	0.9180	0.1051	0.6879	0.0612
I[f]	.49	-	-	0.0020	-
II	.42	-	-	0.0007	-
III	.27	-	-	0.0003	0.0004
IV	.22	-	-	-	0.0001
V	.00	0.0038	0.0066	0.0003	0.0001
Extractable ^{14}C		0.9218	0.1117	0.6912	0.0618
Unextractable ^{14}C		0.0252		0.0760	
Total ^{14}C		1.0587		0.8290	
Sample wt (g)		100.0000		100.0000	

a/ Soil samples were taken 20 days after application of $[^{14}C]$hexachlorobenzene to the soil.

b/ Sediment samples were taken 28 days after application of $[^{14}C]$hexachlorobenzene to the soil, 8 days after flooding the ecosystem with water.

c/ Silica gel GF-254; *n*-hexane : acetone : acetic acid, 40:10:1 by volume.

d/ Methanol extract is from the sample previously extracted with acetone.

e/ Hexachlorobenzene.

f/ Roman numerals = unknown compounds.

Table 94.--Concentrations of [^{14}C]hexachlorobenzene and degradation products in soybean plants [a] after a 14-day exposure in a model ecosystem.

Compound	R_f [c]	Hexachlorobenzene equivalents, ppm [b]		
		Root	Shoot	Entire plant
HCB [d]	.92	1.096	0.024	0.794
I [e]	.90	0.340	0.013	0.248
PCP	.48	0.052	0.005	0.039
V	.40	0.015	0.002	0.011
VIII	.30	-	0.002	<0.001
X	.20	0.006	0.002	0.005
XI	.03-.18 [f]	0.017	0.002	0.013
XIV	.00	0.011	0.001	0.009
Extractable ^{14}C		1.537	0.051	1.119
Unextractable ^{14}C		0.036	0.005	0.028
Total ^{14}C		1.573	0.057	1.147
Average bio-sample wt (g)		0.516	0.202	0.718

[a] [^{14}C]Hexachlorobenzene was applied to the soil beneath each seed.

[b] The roots of 6 soybean plants were combined and analyzed as an individual sample; the shoots were similarly processed.

[c] Silica gel GF-254; n-hexane : acetone : acetic acid, 40:10:1 by volume.

[d] HCB = hexachlorobenzene; PCP = pentachlorophenol.

[e] Roman numerals = unknown compounds.

[f] R_f range denotes a streak on the TLC plate.

Table 95.—Concentrations of [^{14}C]hexachlorobenzene and degradation products in the air[a] from a model ecosystem in which soybeans were grown.

Compound	R_f[c]	Hexachlorobenzene equivalents, ppm Day 0	Trap 1[b] Day 1	Day 5	Day 11	Day 15	Day 19
HCB[d]	.97	0.05090	0.01422	0.00740	0.00245	0.00537	0.01862
I[e]	.82	-	0.00102	-	-	-	-
II	.71	-	0.00032	-	-	-	-
PCP	.57	-	0.00018	-	-	0.00024	-
III	.50	-	-	0.00007	-	-	-
IV	.27	-	0.00027	0.00015	-	-	-
V	.00	-	0.00014	-	-	-	-
Total ^{14}C, Trap 1		0.05090	0.01615	0.00762	0.00245	0.00561	0.01862
Total ^{14}C, Trap 2[f]		0.00019	0.00018	0.00012	0.00007	0.00018	0.00020
Sum ^{14}C, Traps 1 & 2		0.05109	0.01633	0.00774	0.00252	0.00579	0.01882
Sample wt (g)[g]		108.00000	108.00000	108.00000	108.00000	108.00000	108.00000

[a] Air was trapped for a 3-hour daylight period at a flow rate of 10 ml/sec on specified days after application of [^{14}C]hexachlorobenzene to the soil.

[b] Trap 1 was connected directly to the ecosystem container and contained 75 ml of acetonitrile as the trapping solvent; the trapping solvent was chromatographed.

[c] Silica gel GF-254; n-hexane : acetone : acetic acid, 40:10:1 by volume.

[d] HCB = hexachlorobenzene; PCP = pentachlorophenol.

[e] Roman numerals = unknown compounds.

[f] Trap 2 was connected in series to trap 1 and contained 75 ml of trapping solvent (ethanolamine : 2-methoxyethanol, 1:2 by volume); the trap 2 solvent was not chromatographed.

[g] One liter of air was assumed to weigh 1 g.

Table 96.—Concentrations of [^{14}C]hexachlorobenzene and degradation products in invertebrates after a 5-day exposure in a model ecosystem containing soybean plants.

Compound	R_f[a]	Hexachlorobenzene equivalents, ppm			
		Armadillidium[b] (pillbug)	*Estigmene*[c] (caterpillar)	*Limax*[d] (slug)	*Lumbricus*[e] (earthworm)
HCB[f]	.89	1.488	0.564	0.153	4.100
I[g]	.59	-	0.017	0.006	0.103
PCP	.51	-	0.002	0.006	0.028
II	.45	0.005	0.003	0.001	0.019
III	.39	-	0.001	0.001	0.006
IV	.34	-	0.001	-	0.005
V	.25	-	0.001	<0.001	0.003
VI	.18	-	-	0.012	-
VII	.07	-	0.001	0.001	0.002
VIII	.03	0.002	<0.001	0.001	0.002
IX	.00	0.002	<0.001	0.001	0.002
Extractable ^{14}C		1.497	0.590	0.182	4.270
Unextractable ^{14}C		0.037	0.065	0.013	0.191
Total ^{14}C		1.534	0.655	0.195	4.461
Average biosample wt (g)		0.070	1.180	6.756	3.616

[a] Silica gel GF-254; n-hexane : acetone : acetic acid, 40:10:1 by volume.

[b] Three pillbugs were processed together; batch weight = 0.209 g.

[c] Three caterpillars were processed together; batch weight = 3.541 g

[d] Three slugs were processed together; batch weight = 20.268 g.

[e] Three earthworms were processed together; batch weight = 10.849 g.

[f] HCB = hexachlorobenzene; PCP = pentachlorophenol.

[g] Roman numerals = unknown compounds.

Table 97 .—Concentrations of [^{14}C]hexachlorobenzene and degradation products in the prairie vole after a 3-day[a] exposure in a model ecosystem in which soybeans were grown.

Compound	R_f[b]	Hexachlorobenzene equivalents, ppm						
		Skin	Remaining organs[c]	Carcass	Brain	Liver	GI tract	Body totals[d]
HCB[e]	.82	1.419	1.159	0.296	0.250	0.048	0.088	0.484
I[f]	.62	-	-	0.127	0.049	0.013	0.016	0.073
II	.56	-	-	0.047	-	0.022	0.016	0.029
III	.48	0.110	0.064	0.015	-	0.032	0.005	0.031
IV	.42	0.046	0.030	0.023	0.027	0.017	0.003	0.024
V	.36	-	-	0.006	-	-	<0.001	0.003
VI	.34	0.011	0.011	0.003	-	-	<0.001	0.004
VII	.29	0.006	0.008	0.003	-	-	-	0.003
VIII	.28	-	-	0.004	0.015	-	-	0.003
IX	.15-.37[g]	-	-	-	-	0.010	-	0.001
X	.21	0.003	0.003	0.002	-	-	0.001	0.002
XI	.16	0.002	0.002	0.001	-	-	0.001	0.001
XII	.11	0.002	0.005	0.002	-	0.004	0.001	0.002
XIII	.05	0.001	0.002	0.002	-	0.008	0.002	0.002
XIV	.00	0.002	0.002	0.003	0.013	0.005	0.001	0.003
Extractable ^{14}C		1.602	1.286	0.534	0.354	0.159	0.134	0.665
Unextractable ^{14}C		0.108	0.050	0.015	0.002	0.014	0.017	0.030
Total ^{14}C		1.710	1.337	0.549	0.356	0.173	0.151	0.695
Biosample wt (g)		2.762	2.292	11.843	0.452	1.171	2.566	-

[a] The vole died 3 days after being placed in the ecosystem, probably from starvation; the few soybean shoots remaining in the ecosystem when the vole was added had been consumed.

[b] Silica gel GF-254; n-hexane : acetone : acetic acid, 40:10:1 by volume.

[c] Internal organs, other than those specified, were combined and processed as an individual sample.

[d] Body totals were calculated using intact dead body weight (21.639 g).

[e] Hexachlorobenzene.

[f] Roman numerals = unknown compounds.

[g] R_f range denotes a streak on the TLC plate.

Table 98.—Relative affinities of 6 body-parts of the prairie vole[a] for $[^{14}C]$hexachlorobenzene (soybean system) plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-part (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass[b]	43.25	56.17
Skin	31.39	13.10
GI tract	2.57	12.17
Liver	1.34	5.55
Brain	1.07	2.14
Remaining organs[c]	20.37	10.87
	99.99	100.00

[a] Vole from a soil-terrestrial model ecosystem treated with $[^{14}C]$hexachlorobenzene.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

[c] The kidneys + adrenals, heart, lungs, mammary glands, ventral central neck gland and parotid glands were analyzed collectively.

Table 99.—Concentrations of [^{14}C]hexachlorobenzene and degradation products in the water of a model ecosystem (in which soybeans were grown) 7 days after flooding the ecosystem with water[a].

Compound	R_f[c]	Hexachlorobenzene equivalents, ppm			
		Surface water		Leachate[b]	
		Ether-extractable before hydrolysis	Ether-extractable After hydrolysis	Ether-extractable before hydrolysis	Ether-extractable after hydrolysis
HCB[e]	.90	0.00053	0.00007	0.00105	0.00004
PCP	.59	0.00003	0.00002	0.00005	0.00001
III[f]	.44	0.00004	0.00003	0.00003	0.00001
IV	.37	0.00001	0.00001	0.00002	0.00001
V	.27	-	0.00001	-	0.00001
VI	.23	0.00001	0.00003	0.00001	0.00001
VII	.17	0.00001	<0.00001	0.00001	<0.00001
VIII	.10	-	0.00008	-	<0.00001
IX	.06	-	0.00002	-	<0.00001
X	.03	0.00001	0.00002	0.00001	<0.00001
XI	.00	<0.00001	-	<0.00001	<0.00001
Extractable ^{14}C		0.00064	0.00029	0.00118	0.00009
Unextractable ^{14}C		-	0.00027	-	0.00027
Total extractable ^{14}C		0.00093		0.00127	
Unextractable ^{14}C after hydrolysis		0.00027		0.00027	
^{14}C loss during hydrolysis		-0.00003		0.00028	
Initial ^{14}C in water		0.00117		0.00182	
Sample volume (1)		1.00000		1.00000	

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a/ Ecosystem was flooded with water 20 days after application of [^{14}C]hexachlorobenzene to the soil.
b/ One liter of water was withdrawn through the tap at the jar bottom over a period of 1 hr.
c/ Silica gel GF-254; *n*-hexane : acetone : acetic acid, 40:10:1 by volume.
d/ The "unextractable" of the preceding column was adjusted to 0.012 N HCl and maintained at 55-56°C for 18-24 hr.
e/ HCB = hexachlorobenzene; PCP = pentachlorophenol.
f/ Roman numerals = unknown compounds.

Table 100—Concentrations of [^{14}C]hexachlorobenzene and degradation products in aquatic organisms in a model ecosystem (in which soybeans had been grown) flooded with water[a].

		Hexachlorobenzene equivalents, ppm	
Compound	R_f[b]	*Gambusia*[c] (fish)	*Physa*[d] (snail)
HCB[e]	.92	1.361	0.458
I[f]	.77	-	0.061
II	.61	-	0.087
III	.47	0.041	-
IV	.42	-	0.036
V	.38	0.057	0.039
VI	.24	0.024	0.005
VII	.19	-	0.015
VIII	.10	0.295	-
IX	.05	0.067	0.050
X	.00	0.237	0.017
Extractable ^{14}C		2.082	0.768
Unextractable ^{14}C		0.300	0.033
Total ^{14}C		2.383	0.801
Average biosample wt (g)		0.168	0.101

[a] Ecosystem was flooded with water 20 days after application of [^{14}C]-hexachlorobenzene to the soil.

[b] Silica gel GF-254; n-hexane : acetone : acetic acid, 40:10:1 by volume.

[c] Fish were added 4 days after flooding the ecosystem; 2 fish (alive) were removed 3 days later and processed together.

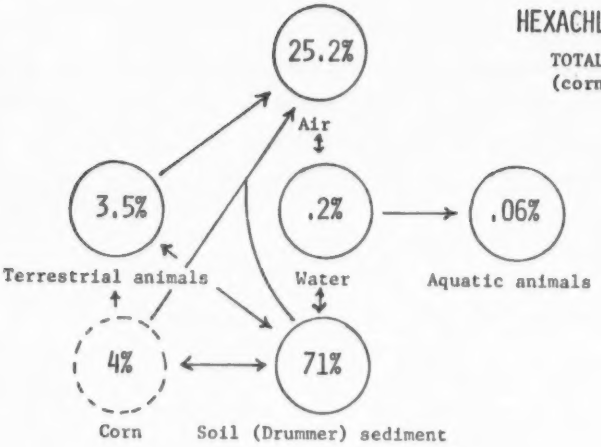
[d] Snails were added on the day of flooding; 15 snails were removed 7 days later and processed as a batch; batch weight = 1.510 g.

[e] Hexachlorobenzene.

[f] Roman numerals = unknown compounds.

HEXACHLOROBENZENE

TOTAL RESIDUE
(corn system)



Calculations of the above estimates:

Ecosystem component	Total maximum mass, g: (No.)	$\overline{X}$ mass	=	total	Mean concentration, μg/g	Total residue, μg: (mass)(conc.)	Total residue as a % of applied dose (5000 μg)
Earthworms	(10)	3.71	=	37.1	.584	21.7	.4
Slugs	(8)	6.50	=	52.0	.228	11.9	.2
Pillbugs	(20)	.0695	=	1.39	4.09	5.69	.1
Caterpillars	(10)	.829	=	8.29	.347	2.88	.06
Vole	(1)	46.5	=	46.5	2.88	134	2.7
Terrestrial animal[a] total (I)				145		176	3.5
Corn[b]	(46)	1.64	=	75.4	2.64	199	4.0
Snails	(50)	.095	=	4.75	.546	2.59	.05
Fish	(3)	.182	=	.546	1.13	.617	.01
Aquatic animal total (II)				5.30		3.21	.06
Surface water (III)	(1)	7000	=	7000	.00173	12.1	.2
Soil sediment[c] (OV)	(1)	4352	=	4352	.818	3560	71.2
Air				[5000 μg-(I+II+III+IV)]		= 1249	25.2

[a] The terrestrial animals (and their residues) were removed from the system at the termination of the terrestrial phase.

[b] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the terrestrial phase, and its residue is distributed among animals, air, and soil.

[c] The direct interaction of corn, air, and terrestrial animals with the soil occurred prior to flooding the system.

Fig. 61.-Terminal environmental distribution of [^{14}C]hexachlorobenzene plus metabolites in a soil-terrestrial model ecosystem.

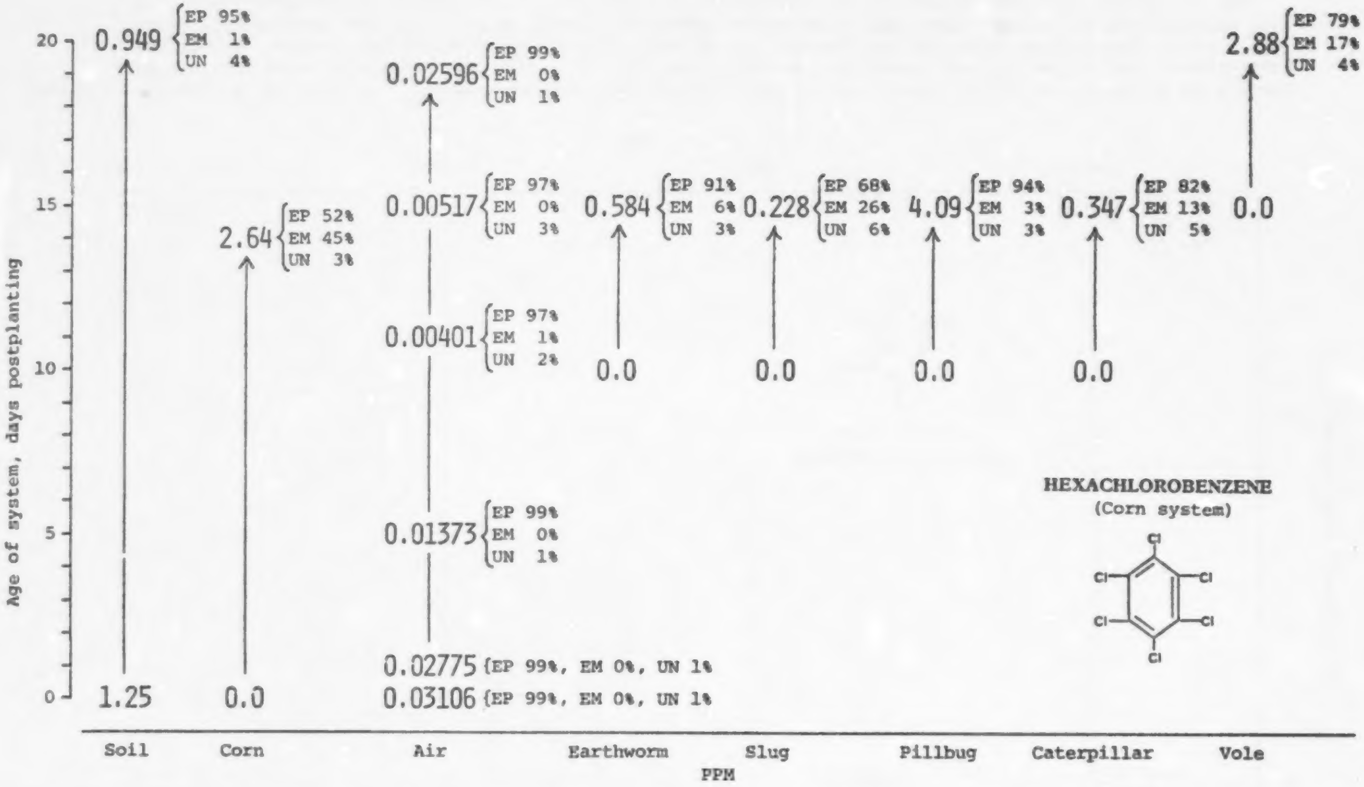


Fig. 62.—Summary of the fate of [^{14}C]hexachlorobenzene (corn system) in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as hexachlorobenzene equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the soil was treated with hexachlorobenzene at one lb AI/acre. On days 10 and 15, the invertebrates and the vole were added, respectively.

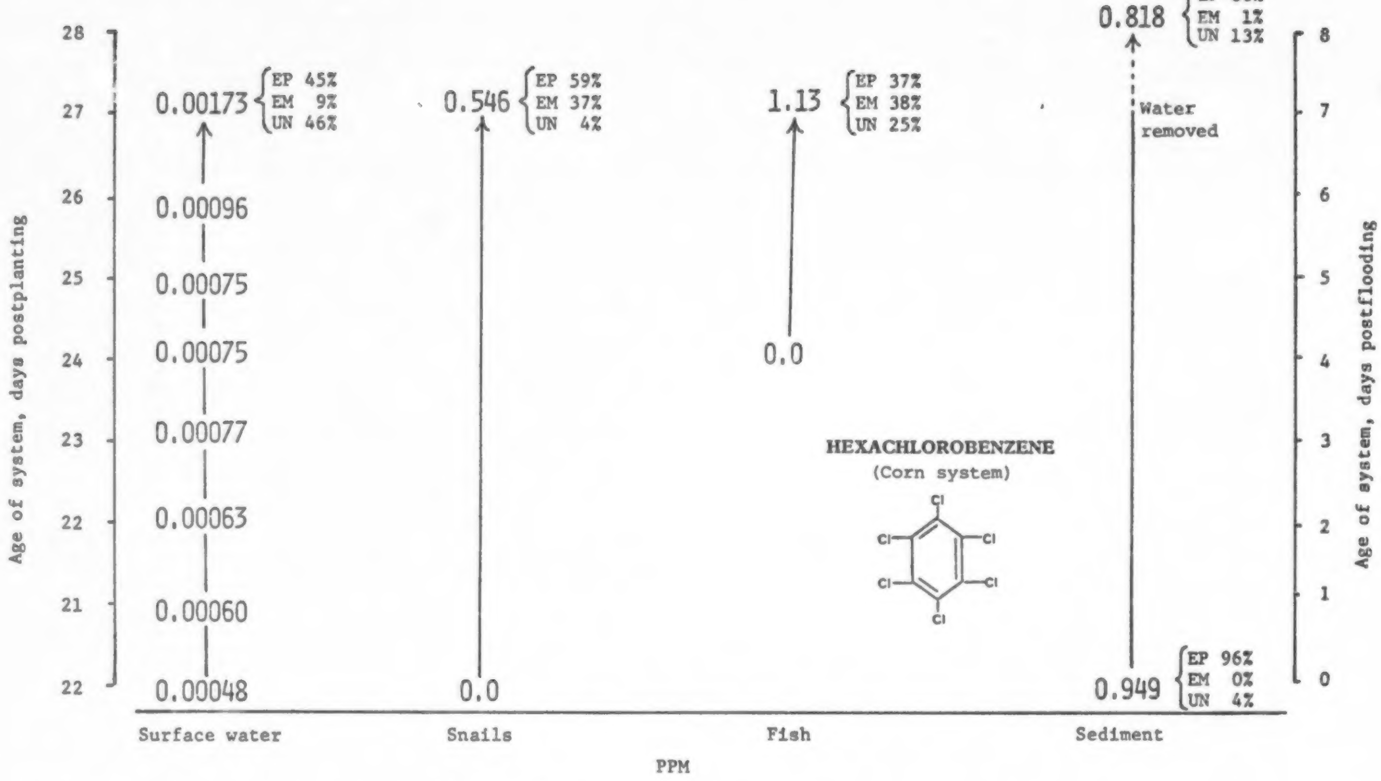


Fig. 63.— Summary of the fate of $[^{14}C]$hexachlorobenzene (corn system) in the aquatic phase; an extension of a soil-terrestrial model ecosystem (see Fig.). The barren terrestrial phase was flooded 20 days postplanting, and snails, daphnia and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as hexachlorobenzene equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 101.—Concentrations of $[^{14}C]$hexachlorobenzene and degradation products in the soil and sediment of a model ecosystem in which corn is grown.

		Hexachlorobenzene equivalents, ppm			
		Soil[a]		Sediment[b]	
Compound	R_f[c]	Acetone extract	Methanol extract[d]	Acetone extract	Methanol extract
HCB[e]	.96	0.8310	0.0729	0.6287	0.0724
I[f]	.52	-	-	0.0023	-
II	.44	-	-	0.0016	-
III	.27	-	-	0.0009	-
IV	.18	-	-	-	0.0001
V	.00	-	0.0040	0.0007	-
Extractable ^{14}C		0.8310	0.0769	0.6342	0.0725
Unextractable ^{14}C		0.0411		0.1111	
Total ^{14}C		0.9490		0.8178	
Sample wt (g)		100.0000		100.0000	

[a] Soil samples were taken 20 days after application of $[^{14}C]$hexachlorobenzene to the soil.

[b] Sediment samples were taken 28 days after application of $[^{14}C]$hexachlorobenzene to the soil, 8 days after flooding the ecosystem with water.

[c] Silica gel GF-254; _n_-hexane : acetone : acetic acid, 40:10:1 by volume.

[d] Methanol extract is from the sample previously extracted with acetone.

[e] Hexachlorobenzene.

[f] Roman numerals = unknown compounds.

Table 102.—Concentrations of [^{14}C]hexachlorobenzene and degradation products in corn[a] after a 14-day exposure in a model ecosystem.

Compound	R_f[c]	Hexachlorobenzene equivalents, ppm[b]		
		Root	Shoot	Entire plant
HCB[d]	.94	2.912	0.037	1.365
I[e]	.90	1.607	0.018	0.752
II	.61-.86[f]	-	0.069	0.037
III	.58	0.516	0.017	0.247
IV	.51	0.099	0.004	0.048
PCP	.44	0.052	0.004	0.026
V	.42	0.057	0.002	0.027
VI	.37	-	0.002	0.001
VII	.35	0.036	-	0.017
IX	.21-.35	-	0.004	0.002
X	.18	0.023	0.001	0.011
XII	.14	0.016	0.001	0.008
XIII	.06	0.018	0.002	0.010
XIV	.00	0.030	0.001	0.015
Extractable ^{14}C		5.366	0.162	2.566
Unextractable ^{14}C		0.145	0.018	0.077
Total ^{14}C		5.511	0.180	2.643
Average biosample wt (g)		0.758	0.883	1.641

[a] [^{14}C]Hexachlorobenzene was applied to the soil beneath each seed.

[b] The roots of 6 corn plants were combined and analyzed as an individual sample; the shoots were similarly processed.

[c] Silica gel GF-254; _n_-hexane : acetone : acetic acid, 40:10:1 by volume.

[d] HCB = hexachlorobenzene; PCP = pentachlorophenol.

[e] Roman numerals = unknown compounds.

[f] R_f range denotes a streak on the TLC plate.

Table 103.—Concentrations of [^{14}C]hexachlorobenzene and degradation products in the air[a] from a model ecosystem in which corn was grown.

Compound	R_f[c]	Hexachlorobenzene equivalents, ppm Trap 1[b] Day 0	Day 1	Day 5	Day 11	Day 15	Day 19
HCB[d]	.96	0.03089	0.02759	0.01357	0.00387	0.00504	0.02570
I[e]	.41	-	-	-	0.00001	-	-
II	.26	-	-	-	0.00003	-	-
Total ^{14}C, Trap 1		0.03089	0.02759	0.01357	0.00391	0.00504	0.02570
Total ^{14}C, Trap 2[f]		0.00017	0.00016	0.00016	0.00010	0.00013	0.00026
Sum ^{14}C, Traps 1 & 2		0.03106	0.02775	0.01373	0.00401	0.00517	0.02596
Sample wt (g)[g]		108.00000	108.00000	108.00000	108.00000	108.00000	108.00000

[a] Air was trapped for a 3-hour daylight period at a flow rate of 10 ml/sec on specified days after application of [^{14}C]hexachlorobenzene to the soil.

[b] Trap 1 was connected directly to the ecosystem container and contained 75 ml of acetonitrile as the trapping solvent; the trapping solvent was chromatographed.

[c] Silica gel GF-254; n-hexane : acetone : acetic acid, 40:10:1 by volume.

[d] Hexachlorobenzene

[e] Roman numerals = unknown compounds.

[f] Trap 2 was connected in series to trap 1 and contained 75 ml of trapping solvent (ethanolamine : 2-methoxyethanol, 1:2 by volume); the trap 2 solvent was not chromatographed.

[g] One liter of air was assumed to weigh 1 g.

Table 104.–Concentrations of $[^{14}C]$hexachlorobenzene and degradation products in invertebrates after a 5-day exposure in a model ecosystem containing corn plants.

		Hexachlorobenzene equivalents, ppm			
Compound	R_f[a]	*Armadillidium*[b] (pillbug)	*Estigmene*[c] (caterpillar)	*Limax*[d] (slug)	*Lumbricus*[e] (earthworm)
HCB[f]	.90	3.848	0.286	0.156	0.530
I[g]	.64	-	0.012	0.006	0.024
PCP	.55	-	0.002	0.015	0.006
II	.46	-	0.001	0.001	0.002
III	.39	-	0.001	0.001	0.001
IV	.32	-	<0.001	-	0.001
V	.23	-	0.001	0.001	<0.001
VI	.17	-	-	0.027	-
VII	.07	0.031	0.006	0.003	<0.001
VIII	.03	0.039	0.008	0.002	<0.001
IX	.00	0.041	0.013	0.003	<0.001
Extractable ^{14}C		3.959	0.330	0.215	0.564
Unextractable ^{14}C		0.133	0.016	0.013	0.020
Total ^{14}C		4.092	0.346	0.228	0.584
Average biosample wt (g)		0.070	0.829	6.503	3.709

[a] Silica gel GF-254; *n*-hexane : acetone : acetic acid, 40:10:1 by volume.

[b] Three pillbugs were processed together; batch weight = 0.209 g.

[c] Three caterpillars were processed together; batch weight = 2.488 g.

[d] Three slugs were processed together; batch weight = 19.510 g.

[e] Three earthworms were processed together; batch weight = 11.127 g.

[f] HCB = hexachlorobenzene; PCP = pentachlorophenol.

[g] Roman numerals = unknown compounds.

Table 105. - Concentrations of [^{14}C]hexachlorobenzene and degradation products in the prairie vole after a 5-day exposure in a model ecosystem in which corn was grown.

Compound	R_f[a]	Hexachlorobenzene equivalents, ppm Fat	Remaining organs[b]	Skin	Carcass	Brain	GI tract	Liver	Body totals[c]
HCB[d]	.84	9.497	5.128	2.877	1.328	0.841	0.676	0.112	2.269
I[e]	.59	-	-	-	0.289	0.125	-	0.018	0.145
II	.57	-	-	-	0.126	-	0.028	0.029	0.067
III	.49	0.195	0.179	0.199	0.147	0.025	0.033	0.120	0.141
IV	.42	0.129	0.058	0.083	0.101	0.060	0.007	0.066	0.080
V	.40	-	-	-	0.044	-	-	-	0.021
VI	.32	-	-	0.020	-	-	0.003	-	0.003
VII	.27	-	-	0.014	-	-	-	-	0.002
IX	.15-.43[f]	-	-	-	-	-	-	0.025	0.002
X	.22	-	0.014	0.006	0.017	-	0.001	-	0.011
XI	.17	-	-	0.004	0.012	-	0.001	-	0.006
XII	.11	-	-	0.003	0.010	-	0.003	0.007	0.006
XIII	.05	-	-	0.003	0.007	0.021	0.002	0.024	0.006
XIV	.00	-	0.015	0.002	0.011	0.016	0.005	0.009	0.009
Extractable ^{14}C		9.821	5.394	3.211	2.092	1.088	0.759	0.410	2.768
Unextractable ^{14}C		0.040	0.040	0.239	0.128	0.008	0.042	0.090	0.110
Total ^{14}C		9.861	5.435	3.450	2.220	1.096	0.801	0.500	2.878
Biosample wt (g)		2.395	6.136	5.623	22.799	0.771	5.616	2.903	-

[a] Silica gel GF-254; n-hexane : acetone : acetic acid, 40:10:1 by volume.
[b] Internal organs, other than those specified, were combined and processed as an individual sample.
[c] Body totals were calculated using live body weight (46.481 g).
[d] Hexachlorobenzene.
[e] Roman numerals = unknown compounds.
[f] R_f range denotes a streak on the TLC plate.

Table 106.—Relative affinities of 7 body-parts of the prairie vole[a] for [^{14}C]hexachlorobenzene (corn system) plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-part (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass[b]	37.84	49.30
Fat	17.66	5.18
Skin	14.50	12.15
GI tract	3.36	12.14
Liver	1.08	6.28
Brain	.63	1.67
Remaining organs[c]	24.92	13.27
	99.99	99.99

[a] Vole from a soil-terrestrial model ecosystem treated with [^{14}C] hexachlorobenzene.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

[c] The kidneys + adrenals, heart, lungs, mammary glands, ventral central neck gland, parotid glands and small amounts of fat tissue were analyzed collectively.

Table 107.-Concentrations of [^{14}C]hexachlorobenzene and degradation products in the water of a model ecosystem (in which corn was grown) 7 days after flooding the ecosystem with water[a].

		Hexachlorobenzene equivalents, ppm			
		Surface water		Leachate[b]	
Compound	R_f[c]	Ether-extractable before hydrolysis	Ether-extractable after hydrolysis[d]	Ether-extractable before hydrolysis	Ether-extractable after hydrolysis
HCB[e]	.92	0.00078	0.00015	0.00295	0.00015
I[f]	.70	-	0.00001	-	0.00003
II	.65	-	-	-	0.00003
PCP	.58	0.00006	0.00001	0.00018	0.00001
III	.44	0.00004	0.00002	0.00006	0.00001
IV	.38	0.00002	0.00001	0.00004	0.00002
V	.28	-	0.00001	-	0.00002
VI	.24	0.00001	0.00001	0.00002	0.00002
VII	.18	0.00001	-	0.00001	0.00002
VIII	.10	-	0.00001	-	0.00003
IX	.06	-	0.00001	-	0.00002
X	.03	0.00001	0.00001	0.00002	<0.00001
XI	.00	<0.00001	<0.00001	0.00001	0.00001
Extractable ^{14}C		0.00093	0.00025	0.00329	0.00037
Unextractable ^{14}C		-	0.00022	-	0.00035
Total extractable ^{14}C		0.00118		0.00366	
Unextractable ^{14}C after hydrolysis		0.00022		0.00035	
^{14}C loss during hydrolysis		0.00033		-0.00009	
Initial ^{14}C in water		0.00173		0.00392	
Sample volume (1)		1.00000		1.00000	

[a] Ecosystem was flooded with water 20 days after application of [^{14}C]hexachlorobenzene to the soil.

[b] One liter of water was withdrawn through the tap at the jar bottom over a period of 1 hr.

[c] Silica gel GF-254; n-hexane : acetone : acetic acid, 40:10:1 by volume.

[d] The "unextractable" of the preceding column was adjusted to 0.012 N HCl and maintained at 55-56°C for 18-24 hr.

[e] HCB = hexachlorobenzene; PCP = pentachlorophenol.

[f] Roman numerals = unknown compounds.

Table 108.-Concentrations of [^{14}C]hexachlorobenzene and degradation products in aquatic organisms in a model ecosystem (in which corn had been grown) flooded with water[a].

		Hexachlorobenzene equivalents, ppm	
Compound	R_f[b]	*Gambusia*[c] (fish)	*Physa*[d] (snail)
HCB[e]	.92	0.420	0.319
I[f]	.75	-	0.046
II	.59	-	0.044
III	.47	0.020	-
IV	.43	-	0.032
V	.39	0.014	0.021
VI	.24	0.006	0.008
VII	.18	-	0.009
VIII	.10	0.063	-
IX	.04	0.098	0.027
X	.00	0.229	0.017
Extractable ^{14}C		0.850	0.523
Unextractable ^{14}C		0.277	0.023
Total ^{14}C		1.127	0.546
Average biosample wt (g)		0.182	0.095

[a] Ecosystem was flooded with water 20 days after application of [^{14}C]-hexachlorobenzene to the soil.

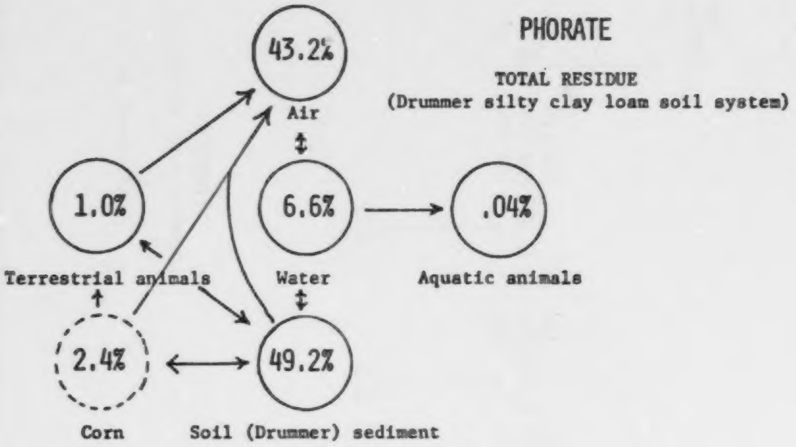
[b] Silica gel GF-254; n-hexane : acetone : acetic acid, 40:10:1 by volume.

[c] Fish were added 4 days after flooding the ecosystem; 2 fish (alive) were removed 3 days later and processed together.

[d] Snails were added on the day of flooding; 15 snails were removed 7 days later and processed as a batch; batch weight = 1.429 g.

[e] Hexachlorobenzene.

[f] Roman numerals = unknown compounds.


PHORATE
TOTAL RESIDUE
(Drummer silty clay loam soil system)
43.2%
Air
1.0%
6.6%
.04%
Terrestrial animals
Water
Aquatic animals
2.4%
49.2%
Corn
Soil (Drummer) sediment

Calculations of the above estimates:

	Total maximum mass, g: (No.)	X̄ mass	= total	Mean concentration, µg/g	Total residue, µg: (mass)(conc.)	Total residue as a % of applied dose (5000 µg)
Earthworms	(10)	3.85	= 38.5	.457	17.6	0.4
Slugs	(8)	8.58	= 68.6	.376	25.8	0.5
Pillbugs	(20)	.0478	= .956	.864	.826	.02
Caterpillars	(10)	.980	= 9.80	.459	4.50	.09
Vole	(1)	20.3	= 20.3	.128	2.60	.05
Terrestrial animal[a] total (I)			138		51.3	1.0
Corn[b]	(50)	1.48	= 74.0	1.59	118	2.4
Snails	(50)	.118	= 5.90	.226	1.33	.03
Fish	(6)	.156	= .936	.527	.493	.01
Aquatic animal total (II)			6.84		1.82	.04
Surface water (III)	(1)	7000	= 7000	.0471	330	6.6
Soil sediments[c] (IV)	(1)	4505	= 4505	.546	2460	49.2
Air			[5000 µg-(I+II+III+IV)]		= 2157	43.2

a/ The terrestrial animals (and their residues) were removed from the system at the termination of the terrestrial phase.

b/ Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the terrestrial phase, and its residue is distributed among animals, air, and soil.

c/ The direct interaction of corn, air, and terrestrial animals with the soil occurred prior to flooding the system.

Fig. 64.-Terminal environmental distribution of $[^{14}C]$phorate plus metabolites in a soil (Drummer)-terrestrial model ecosystem.

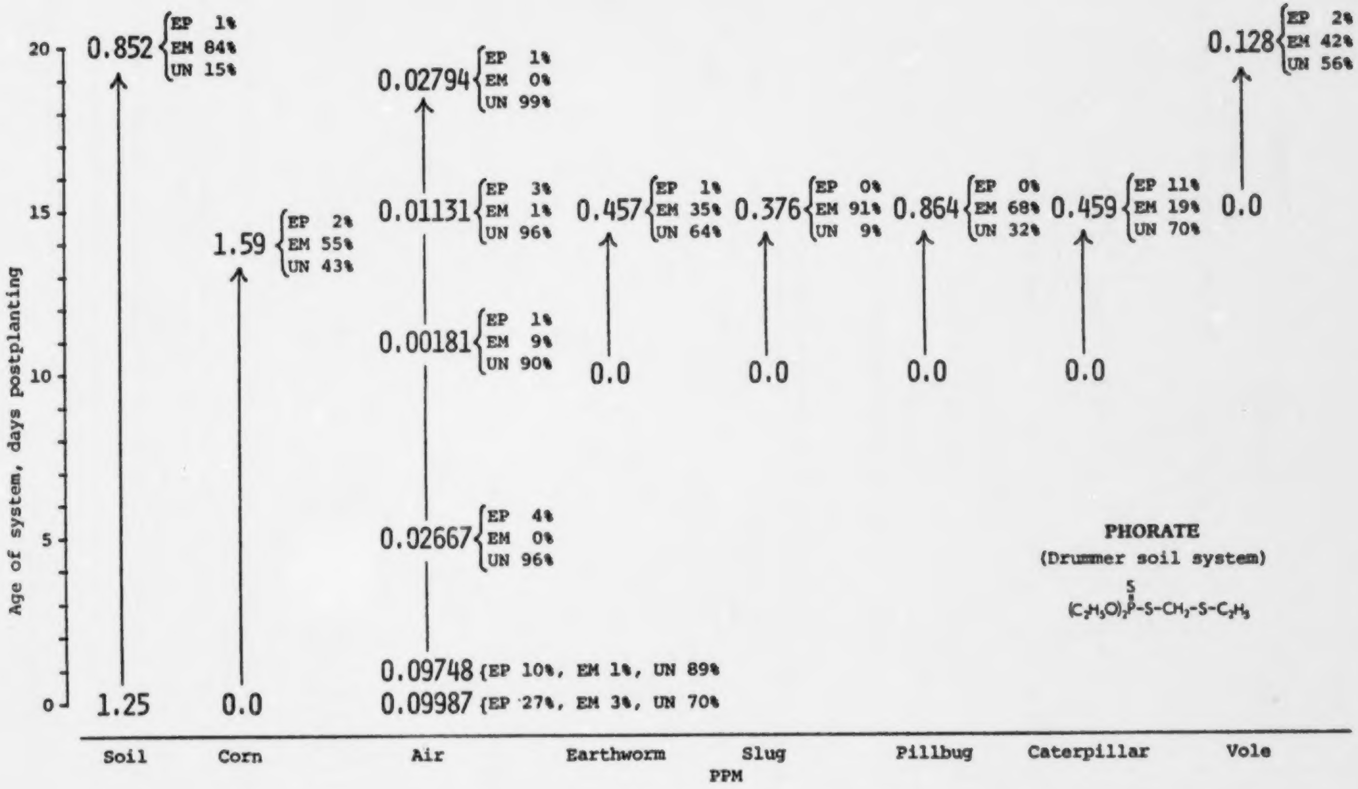


Fig.65 .—Summary of the fate of $[^{14}C]$phorate (Drummer silty clay loam soil system) in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as phorate equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the soil was treated with phorate at one lb AI/acre. On days 10 and 15, the invertebrates and the vole were added, respectively.

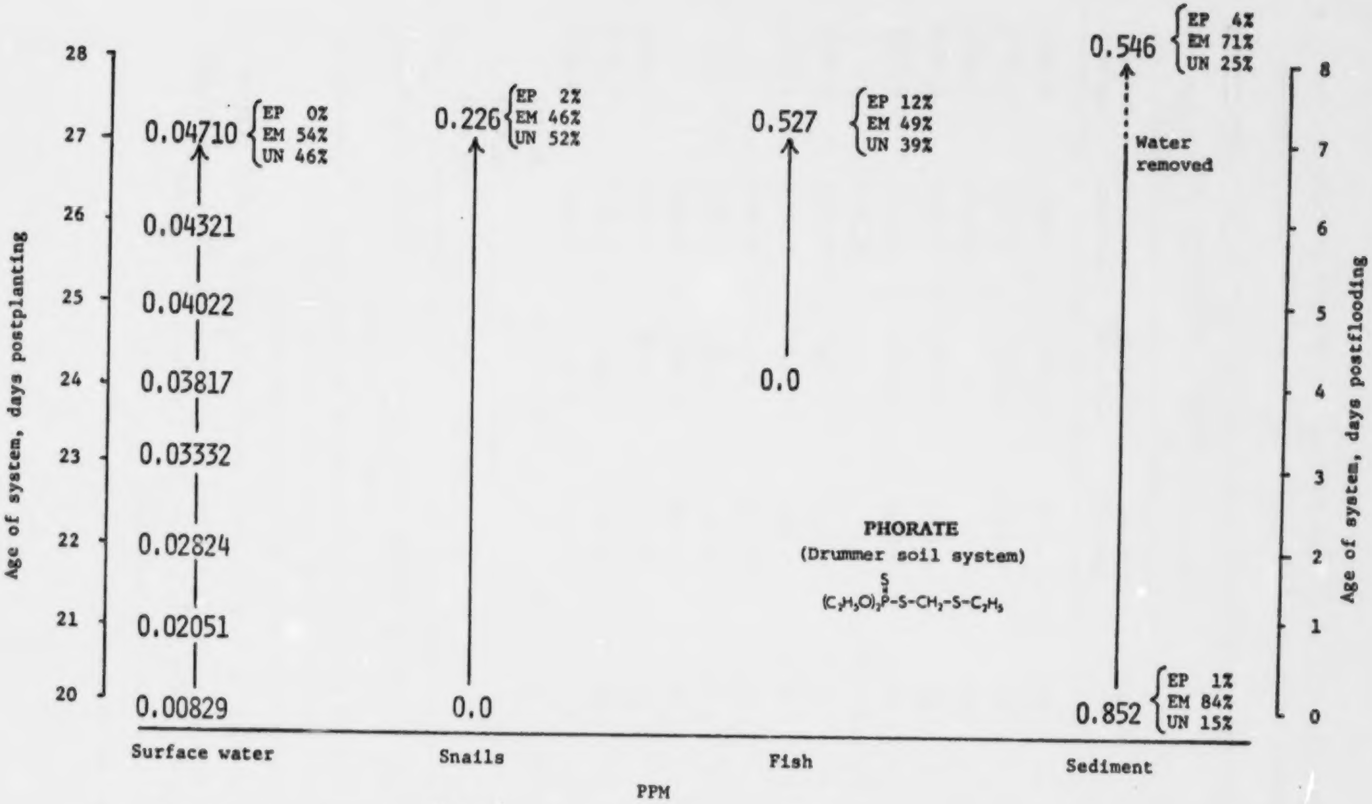


Fig. 66.—Summary of the fate of $[^{14}C]$phorate (Drummer silty clay loam soil) in the aquatic phase; an extension of a soil terrestrial model ecosystem (see Fig.). The barren terrestrial phase was flooded 20 days postplanting and snails, daphnia and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as phorate equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 109.–Concentrations of $[^{14}C]$phorate and degradation products in the Drummer silty clay loam soil and sediment of a model ecosystem.

		Phorate equivalents, ppm			
		Soil[a]		Sediment[b]	
Compound	R_f[c]	Acetone extract	Methanol extract[d]	Acetone extract	Methanol extract
P[e]	.95	0.0086	0.0010	0.0165	0.0054
PSO_2	.88	0.3495	0.0309	0.1916	0.0092
I[f]	.78	-	-	0.0014	0.0001
Px	.65	0.0011	0.0001	0.0004	0.0001
II	.58	0.0032	0.0010	0.0017	0.0002
V	.41-.48[g]	-	-	0.0013	-
$PxSO_2$	.37	0.0075	0.0002	0.0051	0.0001
PSO	.31	0.2625	0.0285	0.1570	0.0033
VI	.21	0.0063	0.0001	0.0007	-
VII	.11-.20	0.0017	0.0003	0.0014	-
VIII	.09	0.0036	0.0004	0.0010	-
PxSO	.06	0.0033	0.0003	0.0040	0.0002
IX	.00	0.0081	0.0049	0.0076	0.0008
Extractable ^{14}C		0.6554	0.0677	0.3897	0.0194
Unextractable ^{14}C		0.1286		0.1364	
Total ^{14}C		0.8517		0.5455	
Sample wt (g)		100.000		100.0000	

a/ Soil samples were taken 20 days after application of $[^{14}C]$phorate to the soil.

b/ Sediment samples were taken 28 days after application of $[^{14}C]$phorate to the soil, 8 days after flooding the ecosystem with water.

c/ Silica gel GF-254; benzene : acetone, 4:1 by volume.

d/ Methanol extract is from the sample previously extracted with acetone.

e/ P = phorate; PSO_2 = phorate sulfone; Px = phoratoxon; $PxSO_2$ = phoratoxon sulfone; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

f/ Roman numerals = unknown compounds.

g/ R_f range denotes a streak on the TLC plate.

Table 110.-Concentrations of $[^{14}C]$phorate and degradation products in corn[a] after a 14-day exposure in a model ecosystem containing Drummer silty clay loam soil.

Compound	R_f[c]	Phorate equivalents, ppm[b]		
		Root	Shoot	Entire plant
P[d]	.93	0.011	0.053	0.038
PSO_2	.76	0.412	0.597	0.530
Px	.57	0.014	0.014	0.014
II[e]	.48	0.004	0.004	0.004
III	.41	0.004	0.007	0.006
$PxSO_2$	.34	0.039	0.041	0.041
PSO	.30	0.068	0.224	0.168
V	.18-.28[f]	0.032	0.015	0.021
VI	.14	0.022	0.011	0.015
VII	.10	0.013	0.011	0.012
PxSO	.06	0.027	0.010	0.016
VIII	.03	0.041	0.015	0.024
IX	.00	0.022	0.023	0.022
Extractable ^{14}C		0.709	1.025	0.911
Unextractable ^{14}C		0.747	0.647	0.683
Total ^{14}C		1.456	1.672	1.594
Average Bio-sample wt (g)		0.534	0.946	1.480

[a] $[^{14}C]$Phorate was applied to the soil beneath each seed.

[b] The roots of 6 corn plants were combined and analyzed as an individual sample; the shoots were similarly processed.

[c] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[d] P = phorate; PSO_2 = phorate sulfone; Px = phoratoxon; $PxSO_2$ = phoratoxon sulfone; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

[e] Roman numerals = unknown compounds.

[f] R_f range denotes a streak on the TLC plate.

Table 111.- Concentrations of [^{14}C]phorate and degradation products in the air[a] from a model ecosystem containing Drummer silty clay loam soil.

		Phorate equivalents, ppm Trap 1[b]					
Compound	R_f[c]	Day 0	Day 1	Day 5	Day 11	Day 15	Day 19
P[d]	.95	0.02730	0.01022	0.00115	0.00001	0.00033	0.00014
PSO_2	.83	-	-	-	0.00015	-	0.00002
I[e]	.57	-	-	-	-	0.00002	-
II	.45	0.00008	-	-	-	-	-
PSO	.38	0.00236	0.00043	0.00007	0.00002	0.00003	0.00003
III	.20	0.00004	-	-	-	0.00002	-
IV	.03-.16[f]	0.00005	-	-	-	-	-
V	.01	0.00003	-	-	-	-	-
Total ^{14}C, Trap 1		0.02986	0.01065	0.00122	0.00018	0.00040	0.00019
Total ^{14}C, Trap 2[g]		0.07001	0.08683	0.02545	0.00163	0.01091	0.02775
Sum ^{14}C, Traps 1 & 2		0.09987	0.09748	0.02667	0.00181	0.01131	0.02794
Sample wt (g)[h]		108.00000	108.00000	108.00000	108.00000	108.00000	108.00000

[a] Air was trapped for a 3-hour daylight period at a flow rate of 10 ml/sec on specified days after application of [^{14}C]phorate to the soil.

[b] Trap 1 was connected directly to the ecosystem container and contained 75 ml of acetonitrile as the trapping solvent; the trapping solvent was chromatographed.

[c] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[d] P = phorate; PSO_2 = phorate sulfone; PSO = phorate sulfoxide.

[e] Roman numerals = unknown compounds.

[f] R_f range denotes a streak on the TLC plate.

[g] Trap 2 was connected in series to trap 1 and contained 75 ml of trapping solvent (ethanolamine : 2-methoxyethanol, 1:2 by volume); the trap 2 solvent was not chromatographed.

[h] One liter of air was assumed to weigh 1 g.

Table 112.—Concentrations of $[^{14}C]$phorate and degradation products in invertebrates after a 5-day exposure in a model ecosystem containing Drummer silty clay loam soil.

		Phorate equivalents, ppm			
Compound	R_f [a]	*Armadillidium* [b] (pillbug)	*Estigmene* [c] (caterpillar)	*Limax* [d] (slug)	*Lumbricus* [e] (earthworm)
P [f]	.92	-	0.049	-	0.003
PSO_2	.75	0.029	0.030	-	0.005
I [g]	.68	-	-	0.014	0.047
II	.51	0.179	0.012	0.234	0.006
PSO	.28	0.021	0.024	-	0.081
III	.09-.26 [h]	-	-	-	0.012
PxSO	.08	0.283	0.006	0.085	0.005
V	.05	-	-	0.004	0.003
VI	.03	0.018	0.003	-	-
VII	.00	0.060	0.014	0.004	0.003
Extractable ^{14}C		0.590	0.138	0.341	0.165
Unextractable ^{14}C		0.274	0.320	0.035	0.292
Total ^{14}C		0.864	0.459	0.376	0.457
Average biosample wt (g)		0.048	0.980	8.579	3.848

[a] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[b] Three pillbugs were processed together; batch weight = 0.143 g.

[c] Three caterpillars were processed together; batch weight = 2.941 g.

[d] Three slugs were processed together; batch weight = 25.737 g.

[e] Three earthworms were processed together; batch weight = 11.545 g.

[f] P = phorate; PSO_2 = phorate sulfone; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

[g] Roman numerals = unknown compounds.

[h] R_f range denotes a streak on the TLC plate.

Table 113.-Concentrations of [^{14}C]phorate and degradation products in the prairie vole after a 5-day exposure in a model ecosystem containing Drummer silty clay loam soil.

Compound	R_f[a]	Phorate equivalents, ppm						
		GI tract	Liver	Remaining organs[b]	Skin	Carcass	Brain	Body totals[c]
P[d]	.95	0.003	<0.001	-	0.001	0.002	0.002	0.002
I[e]	.69-.91[f]	0.007	0.001	-	0.003	0.003	-	0.003
II	.67	0.009	0.001	0.002	0.006	0.008	-	0.006
III	.41-.93	-	-	-	-	-	0.010	<0.001
IV	.54	0.019	0.005	0.002	0.010	0.003	0.019	0.007
V	.42	0.037	0.017	0.042	0.011	0.012	0.011	0.019
PSO	.28	0.032	0.013	0.003	0.004	0.006	0.004	0.010
VII	.12	-	0.002	-	-	-	-	<0.001
PxSO	.09	0.006	0.001	0.005	<0.001	0.006	0.004	0.005
VIII	.04	0.004	0.004	0.001	-	-	0.001	0.001
IX	.00	0.008	0.005	0.003	-	0.003	0.003	0.003
Extractable ^{14}C		0.125	0.049	0.058	0.035	0.043	0.054	0.056
Unextractable ^{14}C		0.266	0.067	0.035	0.048	0.033	0.017	0.071
Total ^{14}C		0.391	0.116	0.093	0.083	0.076	0.072	0.128
Biosample wt (g)		3.075	1.015	1.908	2.476	11.051	0.640	-

[a] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[b] Internal organs, other than those specified, were combined and processed as an individual sample.

[c] Body totals were calculated using live body weight (20.302 g).

[d] P = phorate; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

[e] Roman numerals = unknown compounds.

[f] R_f range denotes a streak on the TLC plate.

Table 114.–Relative affinities of 6 body-parts of the prairie vole[a] for $[^{14}C]$phorate (Drummer-soil system) plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-part (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
GI tract	46.37	15.25
Carcass	32.51	54.80
Skin	7.92	12.28
Liver	4.55	5.03
Brain	1.77	3.17
Remaining organs[c]	6.87	9.46
	99.99	99.99

[a] Vole from a soil-terrestrial model ecosystem treated with $[^{14}C]$phorate.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

[c] The kidneys + adrenals, heart, lungs, mammary glands, ventral central neck gland, and parotid glands were analyzed collectively.

Table 115.—Concentrations of [^{14}C]phorate and degradation products in the water of a model ecosystem (containing Drummer silty clay loam soil) 7 days after flooding the ecosystem with water[a].

		Phorate equivalents, ppm			
		Surface water		Leachate[b]	
Compound	R_f[c]	Ether-extractable before hydrolysis	Ether-extractable after hydrolysis[d]	Ether-extractable before hydrolysis	Ether-extractable after hydrolysis
P[e]	.94	0.00005	0.00002	0.00019	0.00004
PSO_2	.85	0.02055	0.00021	0.07557	0.00053
I[f]	.78	0.00017	0.00006	0.00280	0.00029
II	.60	-	0.00009	-	-
Px	.57	0.00030	0.00005	0.00098	0.00053
III	.53	0.00004	-	0.00009	-
IV	.47	-	-	-	0.00026
V	.43	0.00003	-	0.00012	-
$PxSO_2$	.40	0.00009	-	0.00020	0.00014
PSO	.32	0.00381	0.00053	0.00842	0.00040
VII	.13	0.00006	0.00019	0.00011	0.00033
PxSO	.08	0.00024	0.00010	0.00054	0.00056
IX	.03	-	0.00011	-	0.00045
X	.00	0.00020	0.00026	0.00032	0.00113
Extractable ^{14}C		0.02554	0.00162	0.08934	0.00466
Unextractable ^{14}C		-	0.01576	-	0.05261
Total extractable ^{14}C		0.02716		0.09400	
Unextractable ^{14}C after hydrolysis		0.01576		0.05261	
^{14}C loss during hydrolysis		0.00418		0.00929	
Initial ^{14}C in water		0.04710		0.15590	
Sample volume (1)		1.00000		1.00000	

a/ Ecosystem was flooded with water 20 days after application of [^{14}C]phorate to the soil.

b/ One liter of water was withdrawn through the tap at the jar bottom over a period of 1 hr.

c/ Silica gel GF-254; benzene : acetone, 4:1 by volume.

d/ The "unextractable" of the preceding column was adjusted to 0.012 N HCl and maintained at 55-56°C for 18-24 hr.

e/ P = phorate; PSO_2 = phorate sulfone; Px = phoratoxon; $PxSO_2$ = phoratoxon sulfone; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

f/ Roman numerals = unknown compounds.

Table 116.—Concentrations of [^{14}C]phorate and degradation products in aquatic organisms in a model ecosystem containing Drummer silty clay loam soil and flooded with water[a].

Compound	R_f[b]	Phorate equivalents, ppm *Gambusia*[c] (fish)	 *Physa*[d] (snail)
P[e]	.95	0.063	0.004
PSO_2	.85	0.090	0.054
I[f]	.74	0.016	0.010
Px	.66	0.003	-
II	.61	0.006	0.004
III	.45	-	0.002
$PxSO_2$	.39	0.004	0.001
PSO	.34	0.065	0.013
V	.14	0.006	0.002
VI	.11	0.018	0.001
PxSO	.08	0.011	0.001
VII	.05	0.009	0.001
VIII	.02	0.015	0.002
IX	.00	0.015	0.014
Extractable ^{14}C		0.321	0.109
Unextractable ^{14}C		0.207	0.117
Total ^{14}C		0.528	0.226
Average biosample wt (g)		0.156	0.118

[a] Ecosystem was flooded with water 20 days after application of [^{14}C]-phorate to the soil.

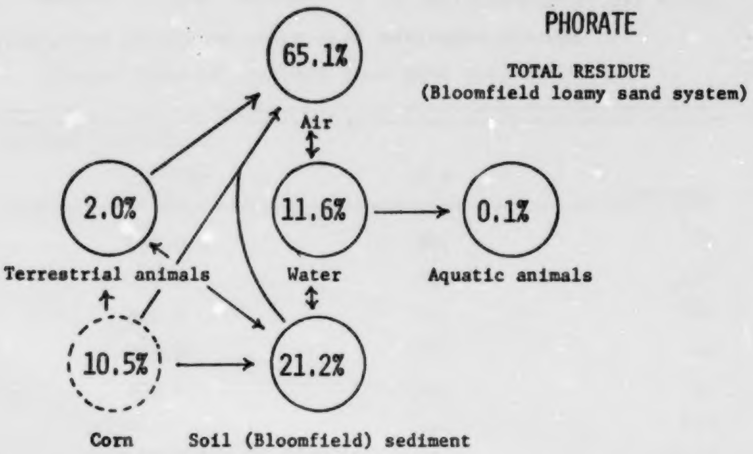
[b] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[c] Three fish were added 4 days after flooding the ecosystem; 3 fish (dead) were removed 2 days later; 3 more fish were added 6 days after flooding the ecosystem; 3 fish (alive) were removed 1.3 days later; the fish were processed in 2 batches (as removed); since the parent compound and metabolite contents of the 2 batches were similar, the results were averaged.

[d] Snails were added on the day of flooding; 15 snails were removed 7 days later and processed as a batch; batch weight = 1.776 g.

[e] P = phorate; PSO_2 = phorate sulfone; Px = phoratoxon; $PxSO_2$ = phoratoxon sulfone; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

[f] Roman numerals = unknown compounds.



PHORATE

TOTAL RESIDUE
(Bloomfield loamy sand system)

Calculations of the above estimates:

Ecosystem component	Total maximum mass, g:			Mean concentration, µg/g	Total residue, µg:	Total residue as a % of applied dose (5000 µg)
	(No.)	$\overline{X}$ mass	= total		(mass)(conc.)	
Earthworms	(10)	2.13	= 21.3	1.91	40.7	0.8
Slugs	(8)	1.79	= 14.3	2.03	29.1	0.6
Pillbugs	(20)	.0507	= 1.01	1.40	1.42	0.03
Caterpillars	(10)	.872	= 8.72	2.01	17.5	0.4
Vole	(1)	22.8	= 22.8	.335	7.64	0.2
Terrestrial animal[a] total (I)			68.1		96.4	2.0
Corn[b]	(50)	1.62	= 81.0	6.48	525	10.5
Snails	(50)	.0997	= 4.99	.821	4.09	.08
Fish	(8)	.170	= 1.36	.772	1.05	.02
Aquatic animal total (II)			6.35		5.14	.1
Surface water (III)	(1)	7000	= 7000	.0832	582	11.6
Soil sediment[c] (IV)	(1)	3770	= 3770	.281	1059	21.2
Air			[5000 µg-(I+II+III+IV)]		= 3257	65.1

a/ The terrestrial animals (and their residues) were removed from the system at the termination of the terrestrial phase.

b/ Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the terrestrial phase, and its residue is distributed among animals, air, and soil.

c/ The direct interaction of corn, air, and terrestrial animals with the soil occurred prior to flooding the system.

Fig. 67.-Terminal environmental distribution of $[^{14}C]$phorate plus metabolites in a soil (Bloomfield)-terrestrial model ecosystem.

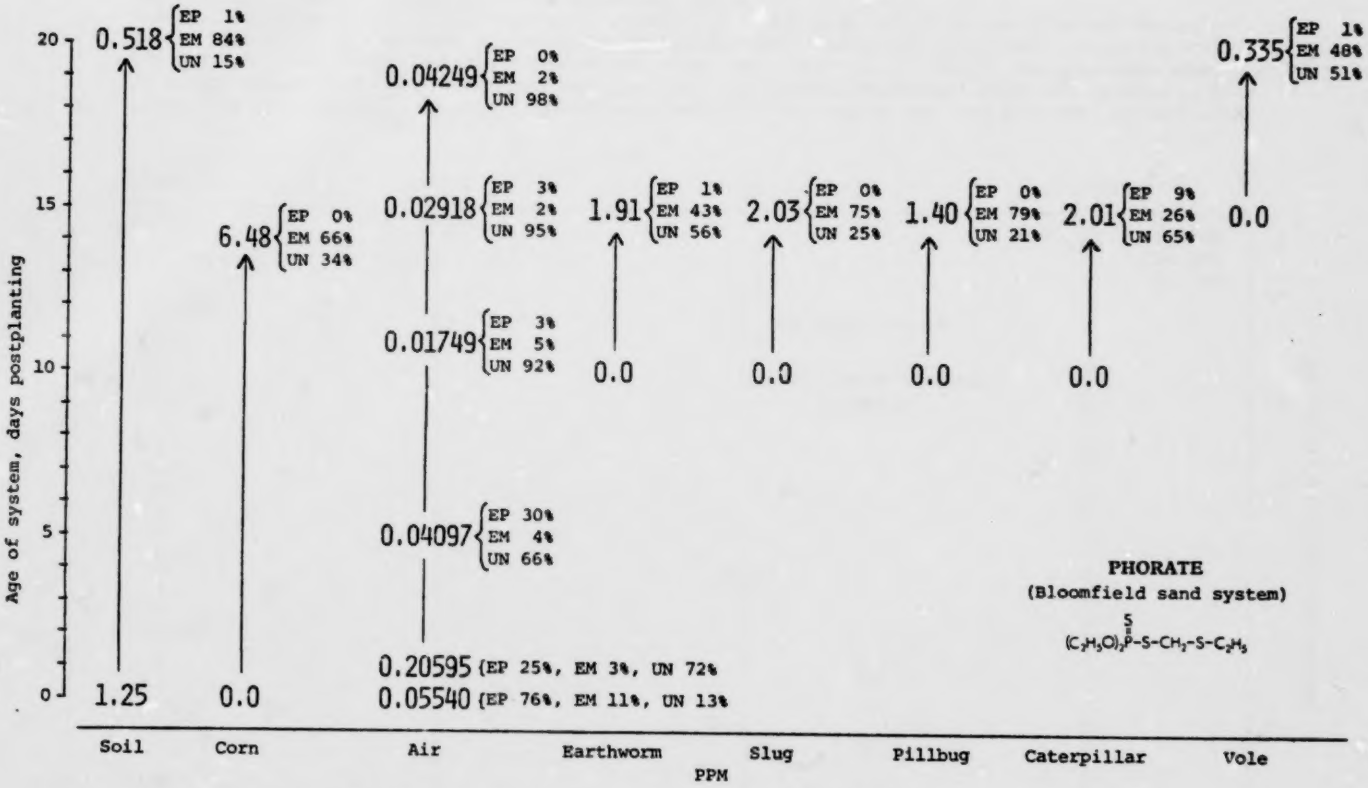


Fig. 68.—Summary of the fate of [^{14}C]phorate (Bloomfield loamy sand system) in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as phorate equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the soil was treated with phorate at one lb AI/acre. On days 10 and 15, the invertebrates and the vole were added, respectively.

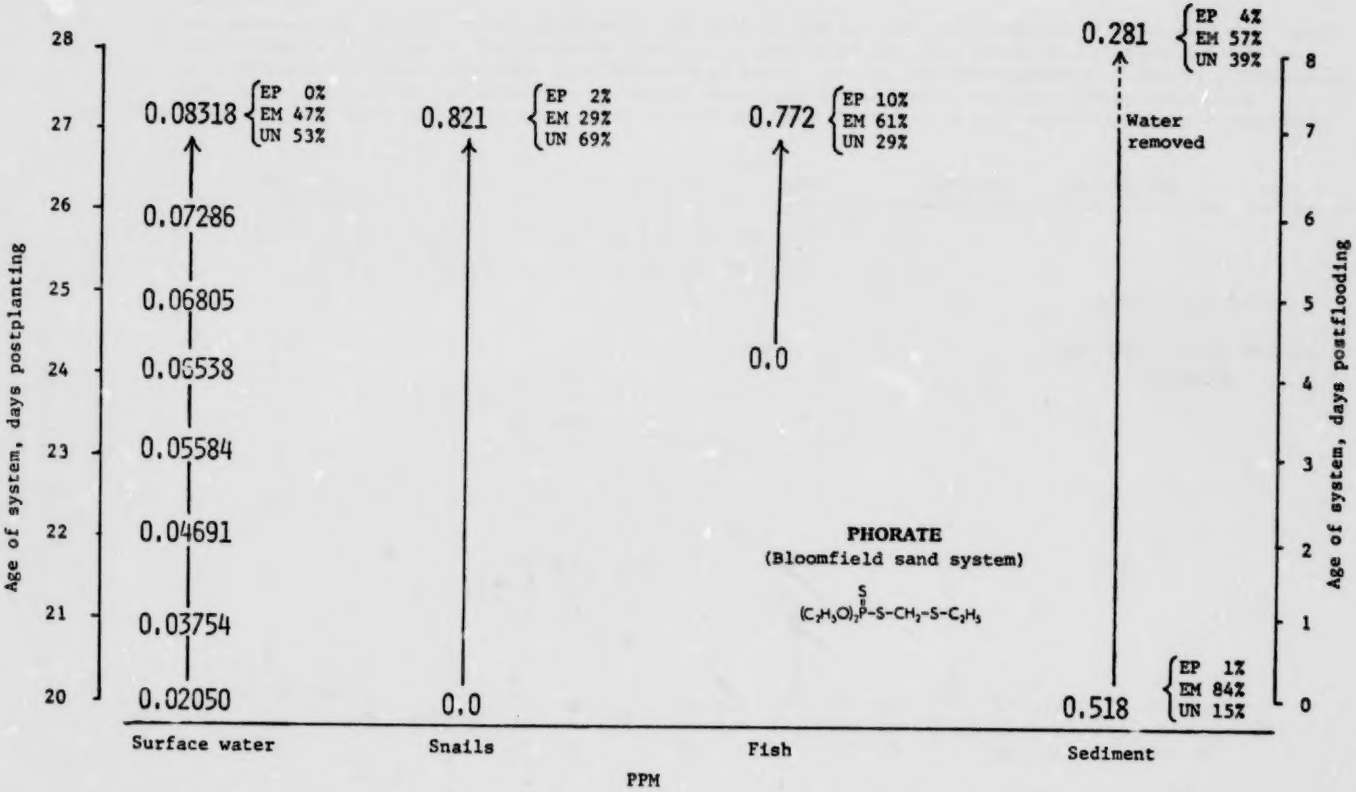


Fig. 69.—Summary of the fate of $[^{14}C]$phorate (Bloomfield loamy sand system) in the aquatic phase; an extension of a soil-terrestrial model ecosystem (see Fig.). The barren terrestrial phase was flooded 20 days postplanting, and snails, daphnia and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as phorate equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 117.-Concentrations of [^{14}C]phorate and degradation products in the Bloomfield loamy sand soil and sediment of a model ecosystem.

Compound	R_f[c]	Phorate equivalents, ppm			
		Soil[a]		Sediment[b]	
		Acetone extract	Methanol extract[d]	Acetone extract	Methanol extract
P[e]	.96	0.0058	0.0015	0.0043	0.0069
PSO_2	.87	0.2703	0.0095	0.0838	0.0141
I[f]	.77	0.0013	-	0.0011	0.0003
Px	.65	0.0011	0.0001	0.0002	0.0001
II	.58	0.0082	0.0003	0.0009	0.0004
III	.52	0.0006	-	0.0005	-
IV	.47	0.0007	-	0.0005	-
V	.39-.46[g]	0.0020	0.0003	0.0007	-
$PxSO_2$	.37	0.0096	0.0002	0.0044	0.0002
PSO	.32	0.0991	0.0057	0.0408	0.0027
VI	.22	0.0006	-	0.0004	-
VII	.10-.20	0.0014	-	0.0011	-
VIII	.09	0.0024	0.0001	0.0005	-
PxSO	.06	0.0025	0.0003	0.0023	0.0003
IX	.00	0.0070	0.0108	0.0036	0.0022
Extractable ^{14}C		0.4126	0.0288	0.1451	0.0272
Unextractable ^{14}C		0.0770		0.1088	
Total ^{14}C		0.5184		0.2811	
Sample wt (g)		100.0000		100.0000	

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[a] Soil samples were taken 20 days after application of [^{14}C]phorate to the soil.

[b] Sediment samples were taken 28 days after application of [^{14}C]phorate to the soil, 8 days after flooding the ecosystem with water.

[c] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[d] Methanol extract is from the sample previously extracted with acetone.

[e] P = phorate; PSO_2 = phorate sulfone; Px = phoratoxon; $PxSO_2$ = phoratoxon sulfone; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

[f] Roman numerals = unknown compounds.

[g] R_f range denotes a streak on the TLC plate.

Table 118.-Concentrations of [^{14}C]phorate and degradation products in corn[a] after a 14-day exposure in a model ecosystem containing Bloomfield loamy sand soil.

Compound	R_f[c]	Phorate equivalents, ppm[b]		
		Root	Shoot	Entire plant
P[d]	.94	0.015	0.062	0.028
PSO_2	.88	0.976	2.160	1.304
I[e]	.78	0.027	0.047	0.032
Px	.70	0.013	0.030	0.018
II	.62	0.024	0.025	0.024
III	.54	0.007	0.016	0.009
IV	.46	0.015	0.027	0.018
$PxSO_2$	.40	0.204	0.337	0.241
PSO	.33	0.648	0.694	0.661
V	.16-.30[f]	0.068	0.118	0.082
VI	.15	0.033	0.041	0.035
VII	.08	0.222	0.196	0.215
PxSO	.05	0.255	0.278	0.261
VIII	.02	0.276	0.355	0.298
IX	.00	0.531	2.403	1.049
Extractable ^{14}C		3.314	6.789	4.275
Unextractable ^{14}C		2.036	2.629	2.200
Total ^{14}C		5.350	9.418	6.476
Average biosample wt (g)		1.169	0.447	1.616

[a] [^{14}C]Phorate was applied to the soil beneath each seed.

[b] The roots of 6 corn plants were combined and analyzed as an individual sample; the shoots were similarly processed.

[c] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[d] P = phorate; PSO_2 = phorate sulfone; Px = phoratoxon; $PxSO_2$ = phoratoxon sulfone; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

[e] Roman numerals = unknown compounds.

[f] R_f range denotes a streak on the TLC plate.

Table 119.-Concentrations of [^{14}C]phorate and degradation products in the air[a] from a model ecosystem containing Bloomfield loamy sand soil.

		Phorate equivalents, ppm Trap 1[b]					
Compound	R_f[c]	Day 0	Day 1	Day 5	Day 11	Day 15	Day 19
P[d]	.96	0.04216	0.05233	0.01215	0.00060	0.00078	0.00010
PSO_2	.85	0.00009	0.00009	0.00012	0.00040	0.00025	0.00019
I[e]	.79	0.00011	0.00022	0.00035	0.00005	0.00004	0.00001
II	.74	-	-	-	-	0.00005	-
III	.57	-	-	-	-	0.00006	-
PSO	.40	0.00602	0.00562	0.00119	0.00041	0.00017	0.00041
IV	.27	0.00003	0.00005	0.00002	-	-	-
V	.23	-	-	-	-	0.00012	-
VI	.14-.21[f]	-	-	-	-	0.00002	-
PxSO	.11	0.00004	0.00005	0.00003	0.00003	0.00003	0.00002
VII	.00	-	0.00004	0.00001	-	0.00001	-
Total ^{14}C, Trap 1		0.04845	0.05840	0.01387	0.00149	0.00153	0.00073
Total ^{14}C, Trap 2[g]		0.00695	0.14755	0.02710	0.01600	0.02765	0.04176
Sum ^{14}C, Traps 1 & 2		0.05540	0.20595	0.04097	0.01749	0.02918	0.04249
Sample wt (g)[h]		108.00000	108.00000	108.00000	108.00000	108.00000	108.00000

[a] Air was trapped for a 3-hour daylight period at a flow rate of 10 ml/sec on specified days after application of [^{14}C]phorate to the soil.

[b] Trap 1 was connected directly to the ecosystem container and contained 75 ml of acetonitrile as the trapping solvert; the trapping solvent was chromatographed.

[c] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[d] P = phorate; PSO_2 = phorate sulfone; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

[e] Roman numerals = unknown compounds.

[f] R_f range denotes a streak on the TLC plate.

[g] Trap 2 was connected in series to trap 1 and contained 75 ml of trapping solvent (ethanolamine : 2-methoxyethanol, 1:2 by volume); the trap 2 solvent was not chromatographed.

[h] One liter of air was assumed to weigh 1 g.

Table 120.—Concentrations of $[^{14}C]$phorate and degradation products in invertebrates after a 5-day exposure in a model ecosystem containing Bloomfield loamy sand soil.

		Phorate equivalents, ppm			
Compound	R_f[a]	*Armadillidium*[b] (pillbug)	*Estigmene*[c] (caterpillar)	*Limax*[d] (slug)	*Lumbricus*[e] (earthworm)
P[f]	.88	-	0.172	-	0.014
PSO_2	.76	-	0.158	0.129	0.314
I[g]	.67	-	-	0.015	-
II	.52	0.551	0.075	1.218	0.136
$PxSO_2$	.33	-	0.016	-	0.007
PSO	.27	0.023	0.042	0.081	0.236
III	.10-.28[h]	-	-	-	0.025
IV	.11	-	0.014	0.014	0.052
PxSO	.08	0.429	0.037	0.063	-
V	.05	-	-	0.005	0.014
VI	.02	0.022	0.044	-	0.014
VII	.00	0.076	0.138	0.009	0.021
Extractable ^{14}C		1.101	0.696	1.534	0.833
Unextractable ^{14}C		0.297	1.311	0.499	1.077
Total ^{14}C		1.398	2.007	2.033	1.910
Average biosample wt (g)		0.051	0.872	1.788	2.129

[a] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[b] Three pillbugs (alive) were processed together; batch weight = 0.152 g.

[c] Three caterpillars (alive) were processed together; batch weight = 2.616 g.

[d] Three slugs (dead) were processed together; batch weight = 5.363 g.

[e] Three earthworms (dead) were processed together; batch weight = 6.387 g.

[f] P = phorate; PSO_2 = phorate sulfone; $PxSO_2$ = phoratoxon sulfone; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

[g] Roman numerals = unknown compounds.

[h] R_f range denotes a streak on the TLC plate.

Table 121.-Concentrations of [^{14}C]phorate and degradation products in the prairie vole after a 5-day exposure in a model ecosystem containing Bloomfield loamy sand soil.

		Phorate equivalents, ppm						
Compound	R$_f$[a]	GI tract	Liver	Remaining organs[b]	Skin	Carcass	Brain	Body totals[c]
P[c]	.96	0.009	0.002	-	-	0.003	0.009	0.004
I[d]	.75-.93[e]	0.017	0.013	-	0.003	0.006	-	0.008
II	.69	0.030	0.006	0.006	0.008	0.004	-	0.010
III	.48-.94	-	-	-	-	-	0.040	0.001
IV	.55	0.181	0.009	0.009	0.049	0.020	0.015	0.054
V	.43	0.148	0.028	0.050	0.018	0.025	0.016	0.049
PSO	.31	0.008	0.033	0.006	0.023	0.016	0.018	0.016
VI	.17	0.011	0.003	-	-	-	-	0.002
PxSO	.09	0.009	0.007	0.005	0.002	0.007	0.005	0.006
VIII	.04	0.015	0.021	0.002	0.001	-	0.005	0.004
IX	.00	0.028	0.022	0.009	0.001	0.004	0.007	0.009
Extractable ^{14}C		0.456	0.144	0.087	0.105	0.085	0.115	0.163
Unextractable ^{14}C		0.113	0.419	0.251	0.171	0.166	0.084	0.172
Total ^{14}C		0.569	0.563	0.338	0.276	0.251	0.199	0.335
Biosample wt (g)		4.395	1.255	1.048	3.200	12.248	0.655	22.801

[a] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[b] Internal organs, other than those specified, were combined and processed as an individual sample.

[c] P = phorate; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

[d] Roman numerals = unknown compounds.

[e] R$_f$ range denotes a streak on the TLC plate.

Table 122.-Relative affinities of 6 body-parts of the prairie vole[a] for $[^{14}C]$phorate (Bloomfield soil system) plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-part (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Carcass[b]	40.15	53.72
GI tract	32.71	19.28
Skin	11.55	14.03
Liver	9.24	5.50
Brain	1.71	2.87
Remaining organs[c]	4.63	4.59
	99.99	99.99

[a] Vole from a soil-terrestrial model ecosystem treated with $[^{14}C]$phorate.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

[c] The kidneys + adrenals, heart, lungs, mammary glands, ventral central neck gland, and parotid glands were analyzed collectively.

Table 123.–Concentrations of [^{14}C]phorate and degradation products in the water of a model ecosystem (containing Bloomfield loamy sand soil) 7 days after flooding the ecosystem with water[a].

		Phorate equivalents, ppm			
		Surface water		Leachate[b]	
Compound	R_f[c]	Ether-extractable before hydrolysis	Ether-extractable after hydrolysis[d]	Ether-extractable before hydrolysis	Ether-extractable after hydrolysis
P[e]	.92	0.00010	0.00007	0.00030	0.00018
PSO_2	.81	0.03313	0.00050	0.12212	0.00435
I[f]	.74	0.00063	0.00016	0.00124	0.00027
II	.68	-	0.00014	-	0.00034
Px	.57	0.00040	0.00012	0.00068	0.00007
III	.53	0.00004	-	0.00014	0.00022
V	.42	0.00003	-	0.00022	-
$PxSO_2$	.38	0.00030	0.00010	0.00054	0.00020
PSO	.31	0.00361	0.00055	0.01243	0.00056
VI	.23	-	0.00005	-	0.00012
VII	.15	0.00013	0.00021	0.00023	0.00044
VIII	.09	-	0.00011	-	0.00028
PxSO	.08	0.00037	0.00030	0.00074	0.00041
IX	.03	-	-	-	0.00033
X	.00	0.00017	0.00028	0.00052	0.00034
Extractable ^{14}C		0.03891	0.00259	0.13916	0.00811
Unextractable ^{14}C		-	0.02484	-	0.06068
Total extractable ^{14}C		0.04150		0.14727	
Unextractable ^{14}C after hydrolysis		0.02484		0.06068	
^{14}C loss during hydrolysis		0.01684		0.01911	
Initial ^{14}C in water		0.08318		0.22706	
Sample volume (1)		1.00000		1.00000	

[a] Ecosystem was flooded with water 20 days after application of [^{14}C]phorate to the soil.

[b] One liter of water was withdrawn through the tap at the jar bottom over a period of 1 hr.

[c] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[d] The "unextractable" of the preceding column was adjusted to 0.012 N HCl and maintained at 55-56°C for 18-24 hr.

[e] P = phorate; PSO_2 = phorate sulfone; Px = phoratoxon; $PxSO_2$ = phoratoxon sulfone; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

[f] Roman numerals = unknown compounds.

Table 124.–Concentrations of [^{14}C]phorate and degradation products in aquatic organisms in a model ecosystem containing Bloomfield loamy sand soil and flooded with water[a].

Compound	R_f[b]	Phorate equivalents, ppm *Gambusia*[c] (fish)	 *Physa*[d] (snail)
P[e]	.94	0.075	0.019
PSO_2	.85	0.161	0.122
I[f]	.72	0.019	0.012
Px	.65	0.004	-
II	.60	0.004	0.007
III	.48	0.002	0.006
$PxSO_2$	.39	0.009	0.003
PSO	.34	0.171	0.015
IV	.15	0.009	-
V	.13	0.005	0.004
VI	.10	0.017	0.005
PxSO	.08	0.022	0.002
VII	.05	0.009	0.002
VIII	.02	0.017	0.004
IX	.00	0.023	0.056
Extractable ^{14}C		0.547	0.257
Unextractable ^{14}C		0.225	0.565
Total ^{14}C		0.772	0.822
Average biosample wt (g)		0.170	0.100

[a] Ecosystem was flooded with water 20 days after application of [^{14}C]-phorate to the soil.

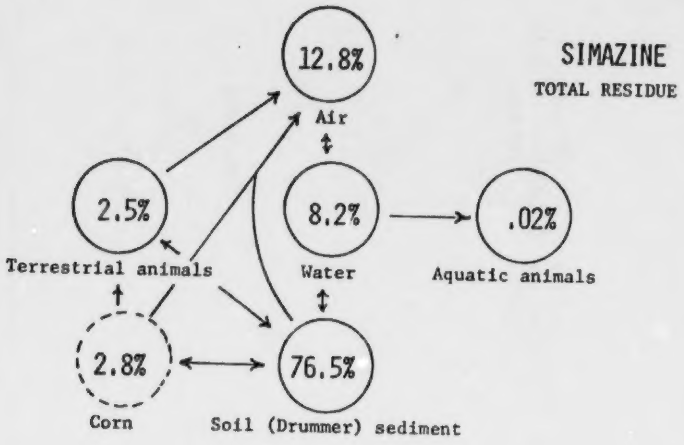
[b] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[c] Three fish were added 4 days after flooding the ecosystem; 2 fish (dead) were removed 1 day later and 1 fish (dead) 1.2 days later; 2 more fish were added 5 days after flooding the ecosystem; 2 fish (dead) were removed 1 day later; 3 more fish were added 6 days after flooding the ecosystem; 2 fish ("sick") and 1 fish (dead) were removed 1.3 days later; the fish were processed in batches (as removed); since the parent compound and metabolite contents of the 5 batches were similar, the results were averaged.

[d] Snails were added on the day of flooding; 15 snails were removed 7 days later and processed as a batch; batch weight = 1.776 g.

[e] P = phorate; PSO_2 = phorate sulfone; Px = phoratoxon; $PxSO_2$ = phoratoxon sulfone; PSO = phorate sulfoxide; PxSO = phoratoxon sulfoxide.

[f] Roman numerals = unknown compounds.



Calculations of the above estimates:

Ecosystem component	Total maximum mass, g: (No.) $\overline{X}$ mass = total	Mean concentration, µg/g	Total residue, µg: (mass)(conc.)	Total residue as a % of applied dose (5000 µg)
Earthworms	(8) 2.91 = 23.3	4.90	114	2.3
Pillbugs	(20) .100 = 2.0	2.01	4.02	.08
Caterpillars	(10) .909 = 9.09	.444	4.04	.08
Vole	(1) 23.8 = 23.8	.0771	1.83	.04
Terrestrial animal[a] total (I)	58.19		124	2.5
Corn[b]	(37) 2.67 = 98.8	1.39	137	2.8
Snails	(50) .155 = 7.75	.133	1.03	.02
Fish	(3) .275 = .825	.207	.171	.003
Aquatic animal total (II)	8.58		1.20	.02
Surface water (III)	(1)7000 = 7000	.0586	410	8.2
Soil sediment[c] (IV)	(1)4306 = 4306	.888	3824	76.5
Air	[5000 µg-(I+II+III+IV)] =		641	12.8

[a] The terrestrial animals (and their residues) were removed from the system at the termination of the terrestrial phase.

[b] Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not presented as an entity at the termination of the terrestrial phase, and its residue is distributed among animals, air, and soil.

[c] The direct interaction of corn, air, and terrestrial animals with the soil occurred prior to flooding the system.

Fig. 70.-Terminal environmental distribution of $[^{14}C]$simazine plus metabolites in a soil-terrestrial model ecosystem.

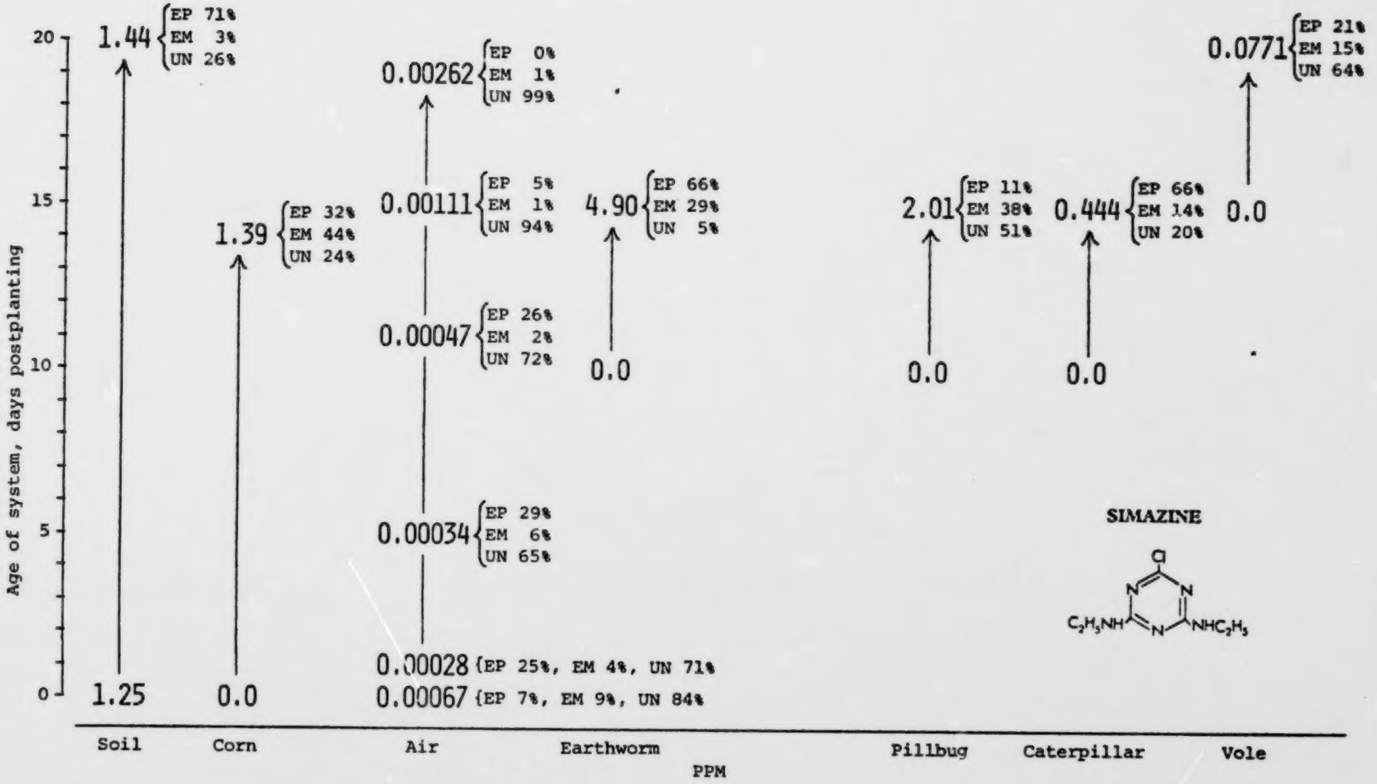


Fig. 71.—Summary of the fate of $[^{14}C]$simazine in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as simazine equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the soil was treated with simazine at one lb AI/acre. On days 10 and 15, the invertebrates and the vole were added, respectively.

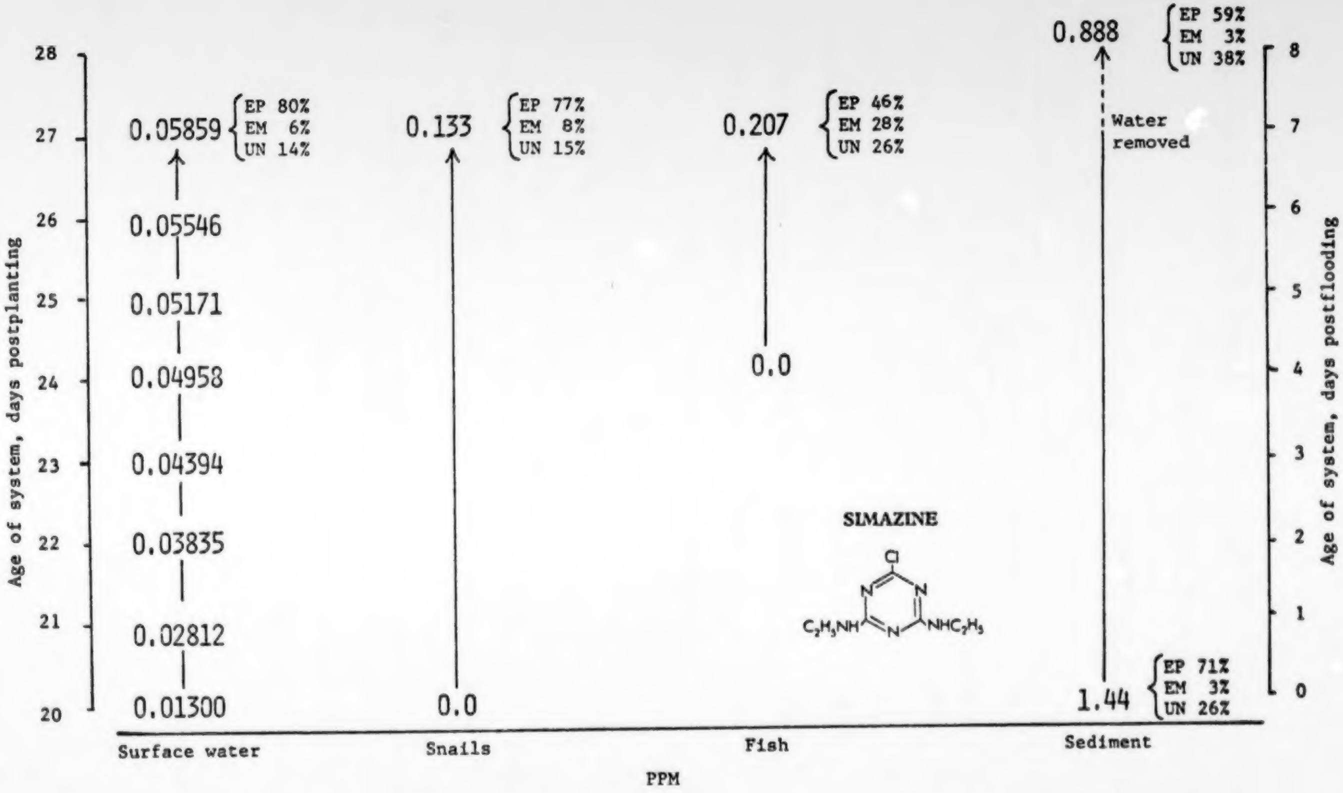


Fig. 72 —Summary of the fate of [^{14}C]simazine in the aquatic phase; an extension of a soil-terrestrial model ecosystem (see Fig.). The barren terrestrial phase was flooded 20 days postplanting, and snails, daphnia and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as simazine equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 125.—Concentrations of [^{14}C]simazine and degradation products in the soil and sediment of a model ecosystem.

		Simazine equivalents, ppm			
		Soil[a]		Sediment[b]	
Compound	R_f[c]	Acetone extract	Methanol extract[d]	Acetone extract	Methanol extract
Simazine	.68	0.8741	0.1408	0.4703	0.0559
I[e]	.35	0.0009	0.0001	0.0010	0.0002
A[f]	.26	0.0284	0.0071	0.0137	0.0024
II	.04	0.0022	0.0013	0.0014	0.0004
III	.00	0.0050	0.0019	0.0041	0.0007
Extractable ^{14}C		0.9106	0.1512	0.4905	0.0596
Unextractable ^{14}C		0.3733		0.3382	
Total ^{14}C		1.4351		0.8883	
Sample wt (g)		100.0000		100.0000	

[a] Soil samples were taken 20 days after application of [^{14}C]simazine to the soil.

[b] Sediment samples were taken 28 days after application of [^{14}C]simazine to the soil, 8 days after flooding the ecosystem with water.

[c] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[d] Methanol extract is from the sample previously extracted with acetone.

[e] Roman numerals = unknown compounds.

[f] 2-chloro, 4-amino, 6-ethylamino-*s*-triazine.

Table 126.–Concentrations of $[^{14}C]$simazine and degradation products in corn[a] after a 14-day exposure in a model ecosystem.

Compound	R_f[c]	Simazine equivalents, ppm[b]		
		Root	Shoot	Entire plant
Simazine	.61	0.593	–	0.448
I[d]	.25–.52[e]	–	0.079	0.019
II	.38	0.003	–	0.003
A[f]	.29	0.015	–	0.011
III	.22	0.011	0.016	0.012
IV	.15	0.006	0.013	0.008
V	.08	0.008	0.024	0.012
VI	.04	0.037	0.177	0.071
VII	.00	0.375	0.794	0.477
Extractable ^{14}C		1.048	1.103	1.061
Unextractable ^{14}C		0.335	0.293	0.325
Total ^{14}C		1.383	1.396	1.386
Average biosample wt (g)		2.022	0.651	2.673

[a] $[^{14}C]$Simazine was applied to the soil beneath each seed.

[b] The roots of 3 corn plants were combined and analyzed as an individual sample; the shoots were similarly processed.

[c] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[d] Roman numerals = unknown compounds.

[e] R_f range denotes a streak on the TLC plate.

[f] 2-Chloro, 4-amino, 6-ethylamino-*s*-triazine.

Table 127.–Concentrations of [^{14}C]simazine and degradation products in the air[a] from a model ecosystem.

Compounds	R_f[c]	Simazine equivalents, ppm Trap 1[b] Day 0	Day 1	Day 5	Day 11	Day 15	Day 19
I[d]	.89	0.00001	0.00001	0.00001	<0.00001	0.00001	0.00002
II	.76	-	<0.00001	0.00001	0.00001	<0.00001	-
Simazine	.70	0.00005	0.00007	0.00010	0.00012	0.00005	<0.00001
III	.41	-	<0.00001	-	-	-	-
A[e]	.30	<0.00001	-	<0.00001	-	0.00001	-
IV	.26	<0.00001	-	-	-	-	-
V	.18	<0.00001	<0.00001	-	-	-	-
VI	.13	0.00003	-	-	-	-	-
VII	.09	0.00001	-	-	-	-	-
VIII	.04	0.00001	-	-	-	-	-
IX	.00	-	-	<0.00001	<0.00001	<0.00001	-
Total ^{14}C, Trap 1		0.00011	0.00008	0.00012	0.00013	0.00007	0.00002
Total ^{14}C, Trap 2[f]		0.00056	0.00020	0.00022	0.00034	0.00104	0.00260
Sum ^{14}C, Traps 1 & 2		0.00067	0.00028	0.00034	0.00047	0.00111	0.00262
Sample wt (g)[g]		108.00000	108.00000	108.00000	108.00000	108.00000	108.00000

[a] Air was trapped for a 3-hour daylight period at a flow rate of 10 ml/sec on specified days after application of [^{14}C]simazine to the soil.

[b] Trap 1 was connected directly to the ecosystem container and contained 75 ml of acetonitrile as the trapping solvent; the trapping solvent was chromatographed.

[c] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[d] Roman numerals = unknown compounds.

[e] 2-chloro, 4-amino, 6-ethylamino-*s*-triazine.

[f] Trap 2 was connected in series to trap 1 and contained 75 ml of trapping solvent (ethanolamine : 2-methoxyethanol, 1:2 by volume); the trap 2 solvent was not chromatographed.

[g] One liter of air was assumed to weigh 1 g.

Table 128.–Concentrations of [^{14}C]simazine and degradation products in invertebrates after a 5-day exposure in a model ecosystem.

Compound	R_f[a]	Simazine equivalents, ppm		
		Armadillidium[b] (pillbug)	*Estigmene*[c] (caterpillar)	*Lumbricus*[d] (earthworm)
I[e]	.74	-	-	0.076
Simazine	.58	0.213	0.292	3.244
II	.39	0.022	-	-
A[f]	.22	0.365	0.052	0.662
III	.12	0.026	-	0.051
IV	.07	-	-	0.069
V	.06	0.209	-	0.095
VI	.04	-	0.003	0.099
VII	.00	0.157	0.006	0.367
Extractable ^{14}C		0.992	0.353	4.663
Unextractable ^{14}C		1.022	0.091	0.236
Total ^{14}C		2.014	0.444	4.900
Average biosample wt (g)		0.100	0.909	2.909

[a] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[b] Three pillbugs were processed together; batch weight = 0.301 g.

[c] Three caterpillars were processed together; batch weight = 2.727 g.

[d] Three earthworms were processed together; batch weight = 8.728 g.

[e] Roman numerals = unknown compounds.

[f] 2-Chloro, 4-amino, 6-ethylamino-*s*-triazine.

Table 129.-Concentrations of [^{14}C]simazine and degradation products in the prairie vole after a 5-day exposure in a model ecosystem.

		Simazine equivalents, ppm							
Compound	R_f[a]	Skin	Liver	Remaining organs[b]	GI tract	Carcass	Fat	Brain	Body totals[c]
I[d]	.94	-	-	-	0.0037	-	-	-	0.0006
Simazine	.86	0.0615	0.0020	0.0054	0.0127	0.0077	0.0039	0.0029	0.0164
II	.71	0.0263	-	-	0.0044	0.0007	-	-	0.0053
III	.58	0.0094	-	-	0.0010	0.0004	-	-	0.0019
A[e]	.39	0.0010	0.0004	-	0.0007	0.0006	-	-	0.0006
IV	.25	0.0002	-	-	0.0004	0.0003	-	-	0.0003
V	.20	0.0005	-	-	0.0003	0.0004	-	-	0.0003
B	.13	0.0006	0.0008	-	0.0003	0.0008	0.0010	-	0.0006
VI	.08	0.0006	0.0005	-	0.0008	0.0002	0.0017	-	0.0004
VII	.04	0.0004	-	-	0.0013	0.0001	-	-	0.0004
VIII	.00	0.0007	0.0005	-	0.0022	0.0007	0.0002	0.0012	0.0009
Extractable ^{14}C		0.1012	0.0042	0.0054	0.0278	0.0119	0.0068	0.0041	0.0277
Unextractable ^{14}C		0.0627	0.1349	0.0601	0.0284	0.0434	0.0480	0.0397	0.0494
Total ^{14}C		0.1639	0.1391	0.0655	0.0562	0.0553	0.0548	0.0438	0.0771
Biosample wt (g)		3.8457	1.2176	1.7057	4.0524	11.3177	0.7254	0.7117	-

[a] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[b] Internal organs, other than those specified, were combined and processed as an individual sample.

[c] Body totals were calculated using live body weight (23.8200 g).

[d] Roman numerals = unknown compounds.

[e] A = 2-chloro, 4-amino, 6-ethylamino-*s*-triazine; B = 2-chloro, 4,6-diamino-*s*-triazine.

Table 130.-Relative affinities of 7 body-parts of the prairie vole[a] for $[^{14}C]$simazine plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-part (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Skin	34.32	16.31
Carcass[b]	34.10	48.00
GI tract	12.40	17.19
Liver	9.22	5.16
Fat	2.17	3.08
Brain	1.70	3.01
Remaining organs[c]	6.09	7.23
	100.00	99.98

[a] Vole from a soil-terrestrial model ecosystem treated with $[^{14}C]$simazine.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

[c] The kidneys + adrenals, heart, lungs, mammary glands, ventral central neck gland, parotid glands and small amounts of fat tissue were analyzed collectively.

Table 131.—Concentrations of [^{14}C]simazine and degradation products in the water of a model ecosystem 7 days after flooding the ecosystem with water[a].

Compound	R_f[b]	Simazine equivalents, ppm Surface water
Simazine	.57	0.04684
A[c]	.22	0.00315
I[d]	.03	0.00009
II	.00	0.00005
Extractable ^{14}C		0.05013
Unextractable ^{14}C[e]		0.01033
^{14}C Loss during extraction		-0.00187
Initial ^{14}C in water		0.05859
Sample volume (1)		1.00000

a/ Ecosystem was flooded with water 20 days after application of [^{14}C]simazine to the soil.

b/ Silica gel GF-254; benzene : acetone, 4:1 by volume.

c/ 2-Chloro, 4-amino, 6-ethylamino-s-triazine.

d/ Roman numerals = unknown compounds.

e/ The water, after ether extraction, was not subjected to the usual hydrolysis procedure.

Table 132.—Concentrations of [^{14}C]simazine and degradation products in aquatic organisms in a model ecosystem flooded with water[a]

Compound	R_f[b]	Simazine equivalents, ppm *Gambusia*[c] (fish)	Simazine equivalents, ppm *Physa*[d] (snail)
I[e]	.86	0.022	-
Simazine	.65	0.096	0.103
A[f]	.31	0.018	0.005
II	.27	0.001	-
III	.21	0.001	-
IV	.14	0.001	-
V	.10	0.002	-
VI	.06	0.002	0.003
VII	.00	0.010	0.002
Extractable ^{14}C		0.153	0.113
Unextractable ^{14}C		0.054	0.020
Total ^{14}C		0.207	0.133
Average biosample wt (g)		0.275	0.155

[a] Ecosystem was flooded with water 20 days after application of [^{14}C]-simazine to the soil.

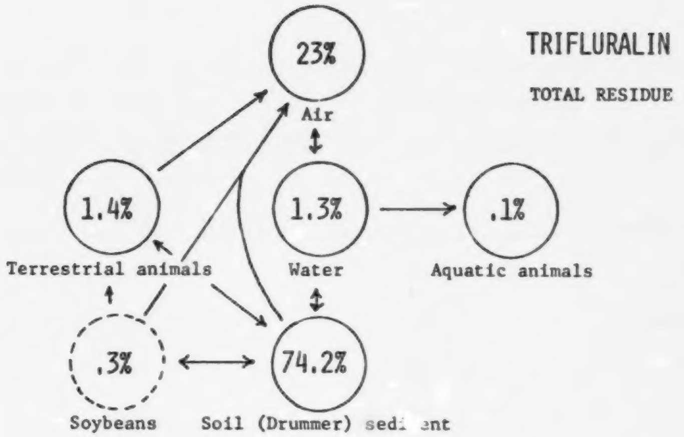
[b] Silica gel GF-254; benzene : acetone, 4:1 by volume.

[c] Fish were added 4 days after flooding the ecosystem; 2 fish (dead) were removed 1 day later and 1 fish (dead) 2 days later; fish were processed individually and the results averaged.

[d] Snails were added on the day of flooding; 15 snails were removed 7 days later and processed as a batch; batch weight = 2.324 g.

[e] Roman numerals = unknown compounds.

[f] 2-Chloro, 4-amino, 6-ethylamino-s-triazine.



Calculations of the above estimates:

Ecosystem component	Total maximum mass, g: (No.)	$\bar{X}$ mass	= total	Mean concentration, μg/g	Total residue, μg: (mass)(conc.)	Total residue as a % of applied dose (5000 μg)
Earthworms	(8)	1.90	= 15.2	4.29	65.2	1.3
Slugs	(1)	.545	= .545	.472	.257	.005
Pillbugs	(20)	.0798	= 1.60	.587	.937	.02
Caterpillars	(5)	.850	= 4.25	.326	1.39	.03
Vole	(1)	18.3	= 18.3	.224	4.10	.08
Terrestrial animal[a] total (I)			39.9		71.9	1.4
Soybeans[b]	(21)	.486	= 10.2	1.56	15.9	.3
Snails	(50)	.182	= 9.10	.571	5.20	.1
Daphnia	(1)	.907	= .907	.146	.132	.003
Fish	(12)	.224	= 2.69	.0591	.159	.003
Aquatic animal total (II)			12.7		5.49	.1
Surface water (III)	(1)	7000	= 7000	.00913	63.9	1.3
Soil sediment[c] (IV)	(1)	4204	= 4204	.882	3708	74.2
Air			[5000 μg-(I+II+III+IV)]		= 1151	23.0

[a] The terrestrial animals (and their residues) were removed from the system at the termination of the terrestrial phase.

[b] Proportion at 14 days postplanting; the soybeans, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the terrestrial phase, and its residue is distributed among animals, air, and soil.

[c] The direct interaction of soybeans, air, and terrestrial animals with the soil occurred prior to flooding the system.

Fig. 73.-Terminal environmental distribution of [^{14}C]trifluralin plus metabolites in a soil-terrestrial model ecosystem.

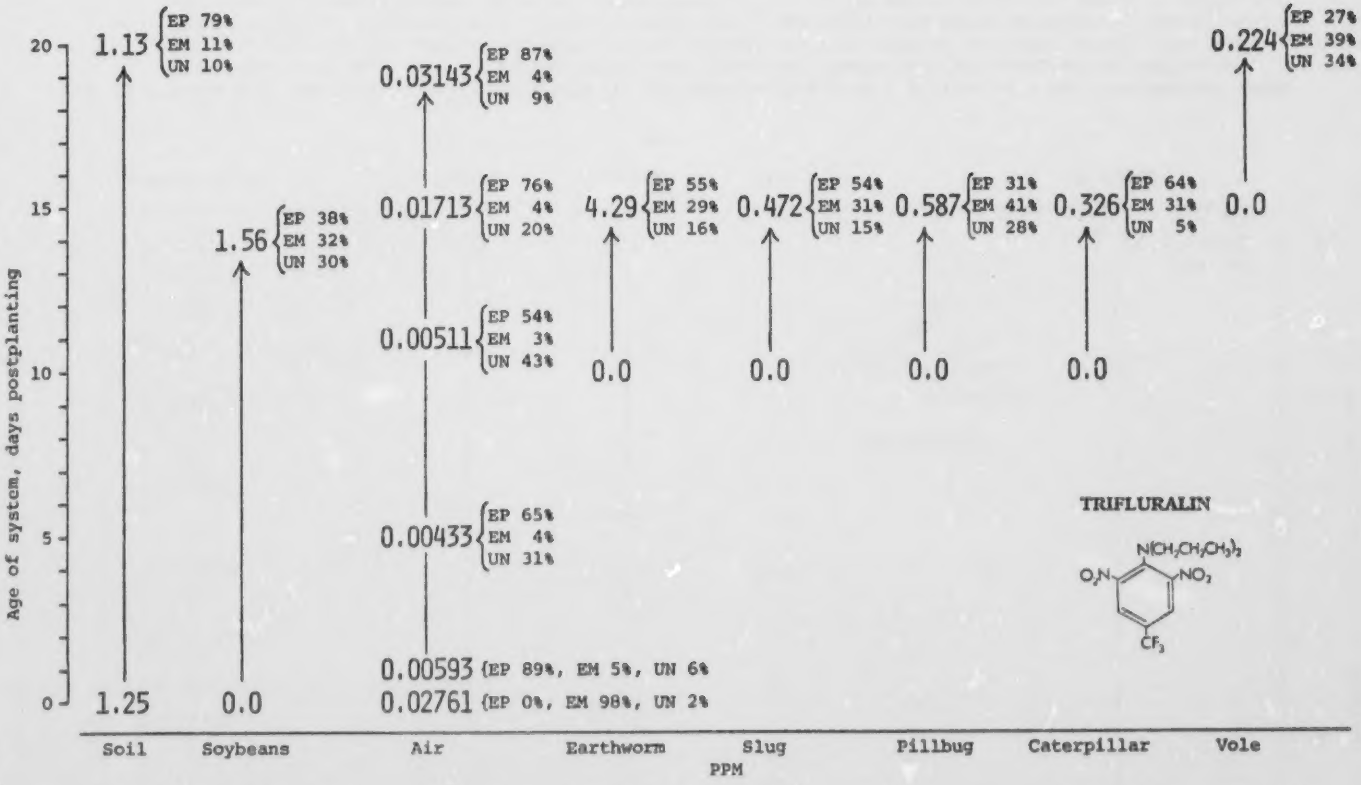


Fig. 74.—Summary of the fate of [^{14}C]trifluralin in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as trifluralin equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the soybean seeds were planted and the soil was treated with trifluralin at one lb AI/acre. On days 10 and 15, the invertebrates and the vole were added, respectively.

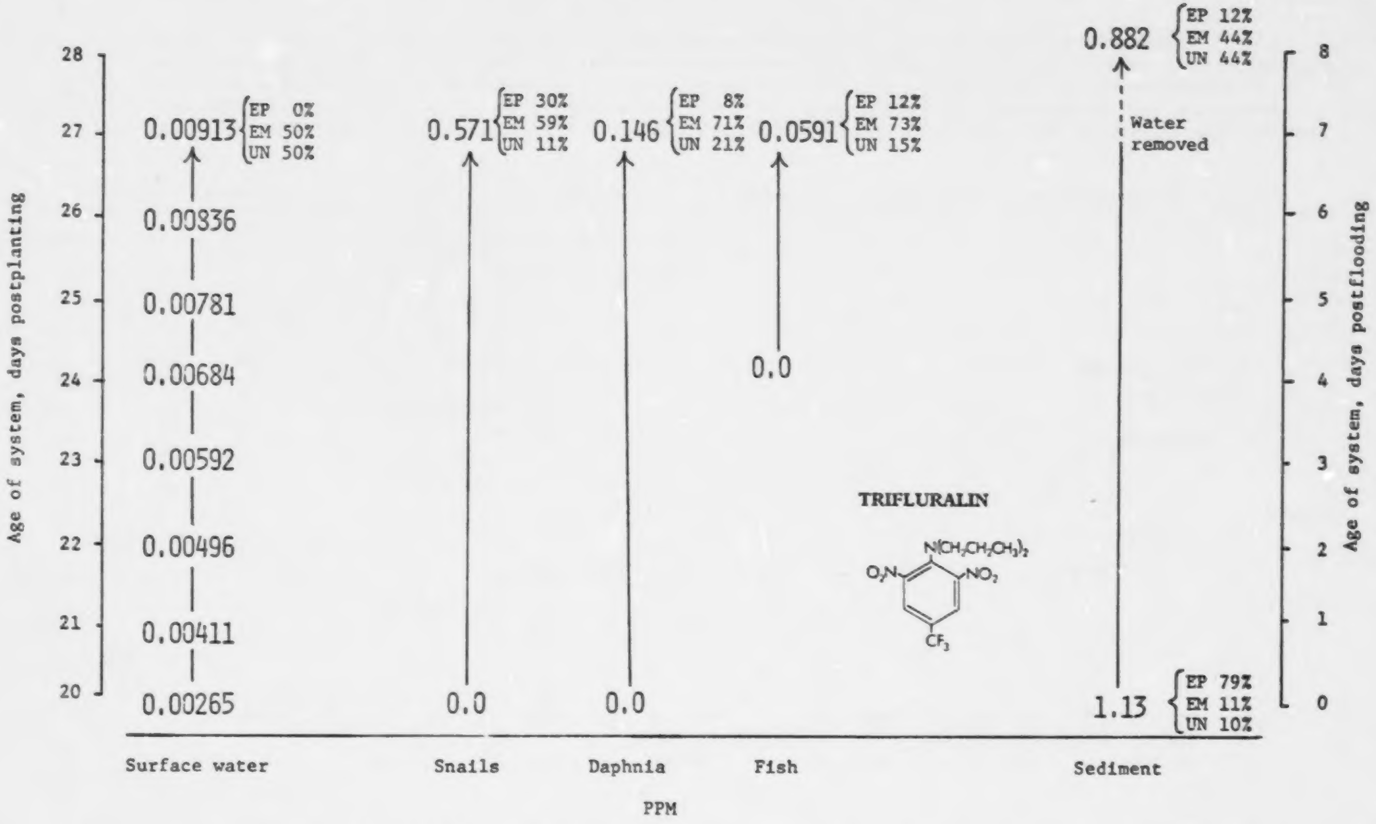


Fig. 75.—Summary of the fate of [^{14}C]trifluralin in the aquatic phase; an extension of a soil-terrestrial model ecosystem (see Fig.). The barren terrestrial phase was flooded 20 days postplanting and snails, Daphnia, and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as trifluralin equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 133.–Concentrations of [^{14}C]trifluralin and degradation products in the soil and sediment of a model ecosystem.

		Trifluralin equivalents, ppm			
		Soil[a]		Sediment[b]	
Compound	R_f[c]	Acetone extract	Methanol extract[d]	Acetone extract	Methanol extract
I[e]	.95	–	–	0.0072	0.0011
T[f]	.91	0.7872	0.1008	0.0905	0.0155
II	.87	–	–	0.0061	0.0017
A	.81	0.0213	0.0033	0.0070	0.0010
III	.72	–	–	0.0024	0.0003
IV	.68	0.0032	0.0005	0.0028	0.0004
V	.61	–	–	0.0061	0.0007
B	.55	0.0115	0.0015	0.0382	0.0107
VI	.46	–	–	0.0049	0.0008
C	.39	0.0047	0.0007	0.0074	0.0008
D	.33	0.0118	0.0016	0.0149	0.0020
VII	.27	0.0015	0.0002	0.0106	0.0014
VIII	.25	–	–	0.0054	0.0010
IX	.21	0.0020	0.0002	0.0114	0.0009
E	.15	0.0092	0.0006	0.0183	0.0023
X	.10	0.0045	0.0018	0.0087	0.0019
XI	.07	0.0061	0.0013	0.0159	0.0038
XII	.03	0.0079	0.0018	0.0355	0.0093
XIII	.00	0.0237	0.0068	0.1300	0.0194
Extractable ^{14}C		0.8946	0.1211	0.4233	0.0750
Unextractable ^{14}C		0.1116		0.3841	
Total ^{14}C		1.1273		0.8824	
Sample wt (g)		100.0000		100.0000	

[a] Soil samples were taken 20 days after application of [^{14}C]trifluralin to the soil.

[b] Sediment samples were taken 28 days after application of [^{14}C]trifluralin to the soil, 8 days after flooding the ecosystem with water.

[c] Silica gel GF-254; n-hexane : acetone, 10:1 by volume.

[d] Methanol extract is from the sample previously extracted with acetone.

[e] Roman numerals = unknown compounds.

[f] T = trifluralin; A = α,α,α-trifluoro-2,6-dinitro-N-propyl-p-toluidine; B = N,N-dipropyl-3-nitro-5-trifluoromethyl-o-phenylenediamine; C = 2,6-dinitro-4-trifluoromethylaniline; D = 2-ethyl-5-trifluoromethyl-7-nitro-1-propylbenzimidazole; E = 2-ethyl-5-trifluoromethyl-7-nitrobenzimidazole.

Table 134.—Concentrations of $[^{14}C]$trifluralin and degradation products in soybean plants[a] after a 14-day exposure in a model ecosystem.

Compound	R_f[c]	Trifluralin equivalents, ppm[b]		
		Root	Shoot	Entire plant
T[d]	.84	0.866	0.005	0.598
A	.68	0.044	0.079	0.055
I[e]	.63	0.011	–	0.007
II	.55	0.043	–	0.029
B	.46	0.018	0.002	0.013
C	.36	0.024	0.005	0.018
D	.31	0.103	0.010	0.074
III	.26	0.015	–	0.011
IV	.22	0.012	–	0.008
V	.18	0.015	0.005	0.012
E	.13	0.013	0.004	0.011
VI	.09	0.023	0.004	0.017
VII	.05	0.117	0.018	0.086
VIII	.00	0.172	0.111	0.153
Extractable ^{14}C		1.476	0.243	1.092
Unextractable ^{14}C		0.599	0.164	0.464
Total ^{14}C		2.076	0.407	1.556
Average biosample wt (g)		0.334	0.151	0.486

a/ $[^{14}C]$Trifluralin was applied to the soil beneath each seed.

b/ The roots of 3 soybean plants were combined and analyzed as an individual sample; the shoots were similarly processed.

c/ Silica gel GF-254; *n*-hexane : acetone, 10:1 by volume.

d/ T = trifluralin; A = α,α,α-trifluoro-2,6-dinitro-*N*-propyl-*p*-toluidine; B = *N*,*N*-dipropyl-3-nitro-5-trifluoromethyl-*o*-phenylenediamine; C = 2,6-dinitro-4-trifluoromethylaniline; D = 2-ethyl-5-trifluoromethyl-7-nitro-1-propylbenzimidazole; E = 2-ethyl-5-trifluoromethyl-7-nitrobenzimidazole.

e/ Roman numerals = unknown compounds.

Table 135.–Concentrations of $[^{14}C]$trifluralin and degradation products in the air[a] from a model ecosystem.

		Trifluralin equivalents, ppm Trap 1[b]					
Compound	R_f[c]	Day 0	Day 1	Day 5	Day 11	Day 15	Day 19
T[d]	.78	0.00009	0.00530	0.00279	0.00278	0.01293	0.02738
A	.67	0.00005	0.00003	0.00001	0.00001	0.00009	0.00019
B	.47	0.00114	0.00001	0.00001	0.00001	0.00002	0.00006
C	.32	0.00066	0.00001	0.00001	-	0.00002	0.00004
D	.26	0.00119	0.00002	0.00001	0.00001	0.00002	0.00005
I[e]	.22	0.00136	0.00001	0.00001	<0.00001	0.00001	0.00002
II	.16	0.00603	-	-	-	-	-
E	.12	0.00079	0.00004	0.00004	0.00003	0.00015	0.00027
III	.09	0.00048	-	-	-	-	-
IV	.07	0.00098	-	-	-	-	-
V	.05	0.00247	0.00004	0.00003	0.00002	0.00010	0.00018
VI	.03	0.00551	0.00003	0.00002	0.00001	0.00008	0.00016
VII	.00	0.00644	0.00008	0.00005	0.00006	0.00027	0.00033
Total ^{14}C, Trap 1		0.02719	0.00557	0.00298	0.00293	0.01369	0.02868
Total ^{14}C, Trap 2[f]		0.00042	0.00036	0.00135	0.00218	0.00344	0.00275
Sum ^{14}C, Traps 1 & 2		0.02761	0.00593	0.00433	0.00511	0.01713	0.03143
Sample wt (g)[g]		108.00000	108.00000	108.00000	108.00000	108.00000	108.00000

[a] Air was trapped for a 3-hour daylight period at a flow rate of 10 ml/sec on specified days after application of $[^{14}C]$trifluralin to the soil.

[b] Trap 1 was connected directly to the ecosystem container and contained 75 ml of acetonitrile as the trapping solvent; the trapping solvent was chromatographed.

[c] Silica gel GF-254; n-hexane : acetone, 10:1 by volume.

[d] T = trifluralin; A = α,α,α-trifluoro-2,6-dinitro-N-propyl-p-toluidine; B = N,N-dipropyl-3-nitro-5-trifluoromethyl-o-phenylenediamine; C = 2,6-dinitro-4-trifluoromethylaniline; D = 2-ethyl-5-trifluoromethyl-7-nitro-1-propylbenzimidazole; E = 2-ethyl-5-trifluoromethyl-7-nitrobenzimidazole.

[e] Roman numerals = unknown compounds.

[f] Trap 2 was connected in series to trap 1 and contained 75 ml of trapping solvent (ethanolamine : 2-methoxyethanol, 1:2 by volume); the trap 2 solvent was not chromatographed.

[g] One liter of air was assumed to weigh 1 g.

Table 136.-Concentrations of [^{14}C]trifluralin and degradation products in invertebrates after a 5-day exposure in a model ecosystem.

		Trifluralin equivalents, ppm			
Compound	R_f[a]	*Armadillidium*[b] (pillbug)	*Estigmene*[c] (caterpillar)	*Limax*[d] (slug)	*Lumbricus*[e] (earthworm)
T[f]	.84	0.182	0.209	0.257	2.349
A	.77	-	0.067	0.019	0.075
I[g]	.75	-	-	0.007	-
B	.59	-	-	0.003	0.039
C	.42	-	-	0.010	0.048
D	.34	0.017	0.009	0.005	0.120
II	.29	-	-	-	0.036
E	.17	-	-	-	0.039
III	.11	-	-	-	0.085
IV	.09	-	-	0.018	0.050
V	.04	0.093	-	0.028	0.306
VI	.00	0.129	0.025	0.057	0.443
Extractable ^{14}C		0.421	0.310	0.404	3.590
Unextractable ^{14}C		0.166	0.016	0.069	0.700
Total ^{14}C		0.587	0.326	0.473	4.291
Average biosample wt (g)		0.080	0.850	0.545	1.902

[a] Silica gel GF-254; n-hexane : acetone, 10:1 by volume.

[b] Three pillbugs were processed together; batch weight = 0.239 g.

[c] Two caterpillars were processed together; batch weight = 1.700 g.

[d] Only one slug (dead) was recovered from ecosystem and processed.

[e] Two earthworms were processed together; batch weight = 3.804 g.

[f] T = trifluralin; A = α,α,α-trifluoro-2,6-dinitro-N-propyl-p-toluidine; B = N,N-dipropyl-3-nitro-5-trifluoromethyl-o-phenylenediamine; C = 2,6-dinitro-4-trifluoromethylaniline; D = 2-ethyl-5-trifluoromethyl-7-nitro-1-propylbenzimidazole; E = 2-ethyl-5-trifluoromethyl-7-nitrobenzimidazole.

[g] Roman numerals = unknown compounds.

Table 137.-Concentrations of $[^{14}C]$trifluralin and degradation products in the prairie vole after a 1.75-day[a] exposure in a model ecosystem.

Compound	R_f[b]	Trifluralin equivalents, ppm						
		GI tract	Skin	Remaining organs[c]	Liver	Brain	Carcass	Body totals
I[d]	.90	0.007	0.017	-	--	-	-	0.004
T[e]	.80	0.142	0.197	0.018	-	-	0.014	0.061
A	.66	0.008	0.012	0.005	-	-	0.003	0.005
B	.52	0.010	0.006	0.006	-	-	0.002	0.004
C	.39	0.001	0.004	0.002	0.002	-	0.003	0.002
D	.31	0.004	0.036	0.007	0.002	-	0.001	0.007
II	.17	0.007	0.009	0.012	0.004	0.011	0.003	0.005
E	.10	0.023	0.012	0.010	-	-	0.004	0.009
III	.04	0.023	0.017	0.022	-	-	0.005	0.011
IV	.00	0.093	0.031	0.078	0.083	0.102	0.013	0.041
Extractable ^{14}C		0.318	0.341	0.160	0.091	0.113	0.048	0.149
Unextractable ^{14}C		0.184	0.116	0.091	0.057	0.007	0.033	0.076
Total ^{14}C		0.502	0.457	0.251	0.148	0.121	0.081	0.225
Biosample wt (g)		3.400	2.431	1.139	0.909	0.541	9.860	18.281

[a] The vole died 1.75 days after being placed in the ecosystem, probably from starvation; essentially no soybean shoots were present in the ecosystem when the vole was added; rabbit chow was added but not eaten.

[b] Silica gel GF-254; n-hexane : acetone, 10:1 by volume.

[c] Internal organs, other than those specified, were combined and processed as an individual sample.

[d] Roman numerals = unknown compounds.

[e] T = trifluralin; A = α,α,α-trifluoro-2,6-dinitro-N-propyl-p-toluidine; B = N,N-dipropyl-3-nitro-5-trifluoromethyl-o-phenylenediamine; C = 2,6-dinitro-4-trifluoromethylaniline; D = 2-ethyl-5-trifluoromethyl-7-nitro-1-propylbenzimidazole; E = 2-ethyl-5-trifluoromethyl-7-nitrobenzimidazole.

Table 138.–Relative affinities of 6 body-parts of the prairie vole[a] for $[^{14}C]$trifluralin plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-part (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
GI tract	41.58	18.60
Skin	27.11	13.30
Carcass[b]	19.46	53.94
Liver	3.28	4.97
Brain	1.59	2.96
Remaining organs[c]	6.98	6.23
	100.00	100.00

[a] Vole from a soil-terrestrial model ecosystem treated with $[^{14}C]$trifluralin.

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

[c] The kidneys + adrenals, heart, lungs, mammary glands, ventral central neck gland, and parotid glands were analyzed collectively.

Table 139.-Concentrations of $[^{14}C]$trifluralin and degradation products in the water of a model ecosystem 7 days after flooding the ecosystem with water[a].

Compound	R_f[b]	Trifluralin equivalents, ppm Surface water
D[c]	.26	0.00093
E	.12	0.00028
I[d]	.06	0.00043
II	.02	0.00127
III	.00	0.00162
Extractable ^{14}C		0.00453
Unextractable ^{14}C[e]		0.00453
^{14}C Loss during extraction		0.00007
Initial ^{14}C in water		0.00913
Sample volume (1)		1.00000

[a] Ecosystem was flooded with water 20 days after application of $[^{14}C]$trifluralin to the soil.

[b] Silica gel GF-254; n-hexane : acetone, 10:1 by volume.

[c] D = 2-ethyl-5-trifluoromethyl-7-nitro-1-propylbenzimidazole;
E = 2-ethyl-5-trifluoromethyl-7-nitrobenzimidazole.

[d] Roman numerals = unknown compounds.

[e] The water, after ether extraction, was not subjected to the usual hydrolysis procedure.

Table 140.—Concentrations of [^{14}C]trifluralin and degradation products in aquatic organisms in a model ecosystem flooded with water[a].

Compound	R_f[b]	Trifluralin equivalents, ppm *Gambusia*[c] (fish)	*Physa*[d] (snail)	*Daphnia*[e] (water flea)
I[f]	.87	0.015	0.016	-
T[g]	.77	0.007	0.170	0.012
A	.62	0.001	0.011	0.002
B	.43	0.007	0.069	0.037
C	.33	0.002	0.013	0.003
D	.31	-	0.004	0.004
II	.27	0.002	0.011	-
III	.22	-	0.007	-
E	.12	0.002	0.014	0.002
IV	.08	-	0.012	0.002
V	.06	-	0.019	0.002
VI	.04	0.006	0.067	0.009
VII	.00	0.008	0.098	0.043
Extractable ^{14}C		0.050	0.511	0.116
Unextractable ^{14}C		0.009	0.060	0.031
Total ^{14}C		0.059	0.571	0.147
Average biosample wt (g)		0.224	0.182	0.907

[a] Ecosystem was flooded with water 20 days after application of [^{14}C]-trifluralin to the soil.

[b] Silica gel GF-254; *n*-hexane : acetone, 10:1 by volume.

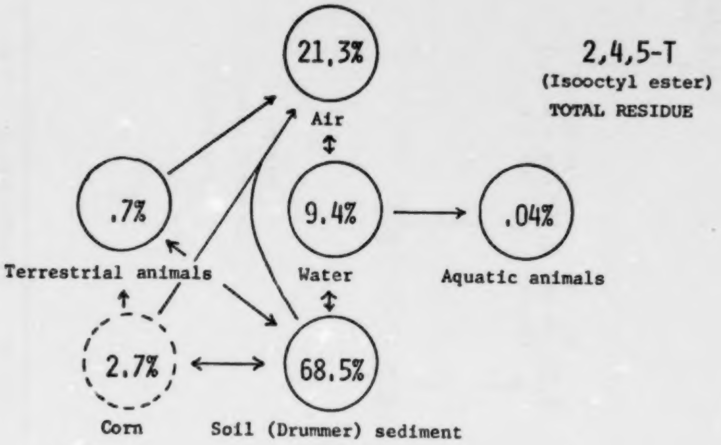
[c] Three fish were added 4 days after flooding the ecosystem; 3 fish (dead) were removed 5 hr later; 3 more fish were added 4.2 days after flooding the ecosystem; 3 fish (dead) were removed 17 hr later; 3 more fish were added 5 days after flooding the ecosystem; 2 fish (dead) were removed 1 hr later and 1 fish (dead) 2.5 hr later; 3 more fish were added 5.14 days after flooding the ecosystem; 3 fish (dead) were removed 0.5 hr later; the fish were processed in batches (as removed), and the results averaged.

[d] Snails were added on the day of flooding; 15 snails were removed 7 days later and processed as a batch; batch weight = 2.730 g.

[e] Daphnia were added on the day of flooding, removed 7 days later, and processed as a batch; many organisms constituted the biosample.

[f] Roman numerals = unknown compounds.

[g] T = trifluralin; A = α,α,α-trifluoro-2,6-dinitro-*N*-propyl-*p*-toluidine; B = *N*,*N*-dipropyl-3-nitro-5-trifluoromethyl-*o*-phenylenediamine; C = 2,6-dinitro-4-trifluoromethylaniline; D = 2-ethyl-5-trifluoromethyl-7-nitro-1-propylbenzimidazole; E = 2-ethyl-5-trifluoromethyl-7-nitrobenzimidazole.



Calculations of the above estimates:

Ecosystem component	Total maximum mass, g: (No.)	$\overline{X}$ mass	= total	Mean concentration, µg/g	Total residue, µg: (mass)(conc.)	Total residue as a % of applied dose (5000 µg)
Earthworms	(8)	2.15	= 17.2	1.81	31.1	.6
Pillbugs	(20)	.0580	= 1.16	2.69	3.12	.06
Caterpillars	(10)	.912	= 9.12	.163	1.49	.03
Vole	(1)	26.3	= 26.3	.0361	.949	.02
Terrestrial animal[a] total (I)			53.8		36.7	.7
Corn[b]	(45)	2.76	= 124	1.09	135	2.7
Snails	(50)	.168	= 8.40	.193	1.62	.03
Daphnia	(1)	.567	= .567	.231	.131	.003
Fish	(6)	.233	= 1.40	.149	.208	.004
Aquatic animal total (II)			10.4		1.96	.04
Surface water (III)	(1)	7000	= 7000	.0673	471	9.4
Soil sediment[c] (IV)	(1)	4306	= 4306	.795	3423	68.5
Air			[5000 µg-(I+II+III+IV)]		= 1067	21.3

a/ The terrestrial animals (and their residues) were removed from the system at the termination of the terrestrial phase.

b/ Proportion at 14 days postplanting; the corn, having been consumed and/or demolished by the animals, is not present as an entity at the termination of the terrestrial phase, and its residue is distributed among animals, air, and soil.

c/ The direct interaction of corn, air, and terrestrial animals with the soil occurred prior to flooding the system.

Fig. 76.-Terminal environmental distribution of $[^{14}C]$2,4,5-T (isooctyl ester) plus metabolites in a soil-terrestrial model ecosystem.

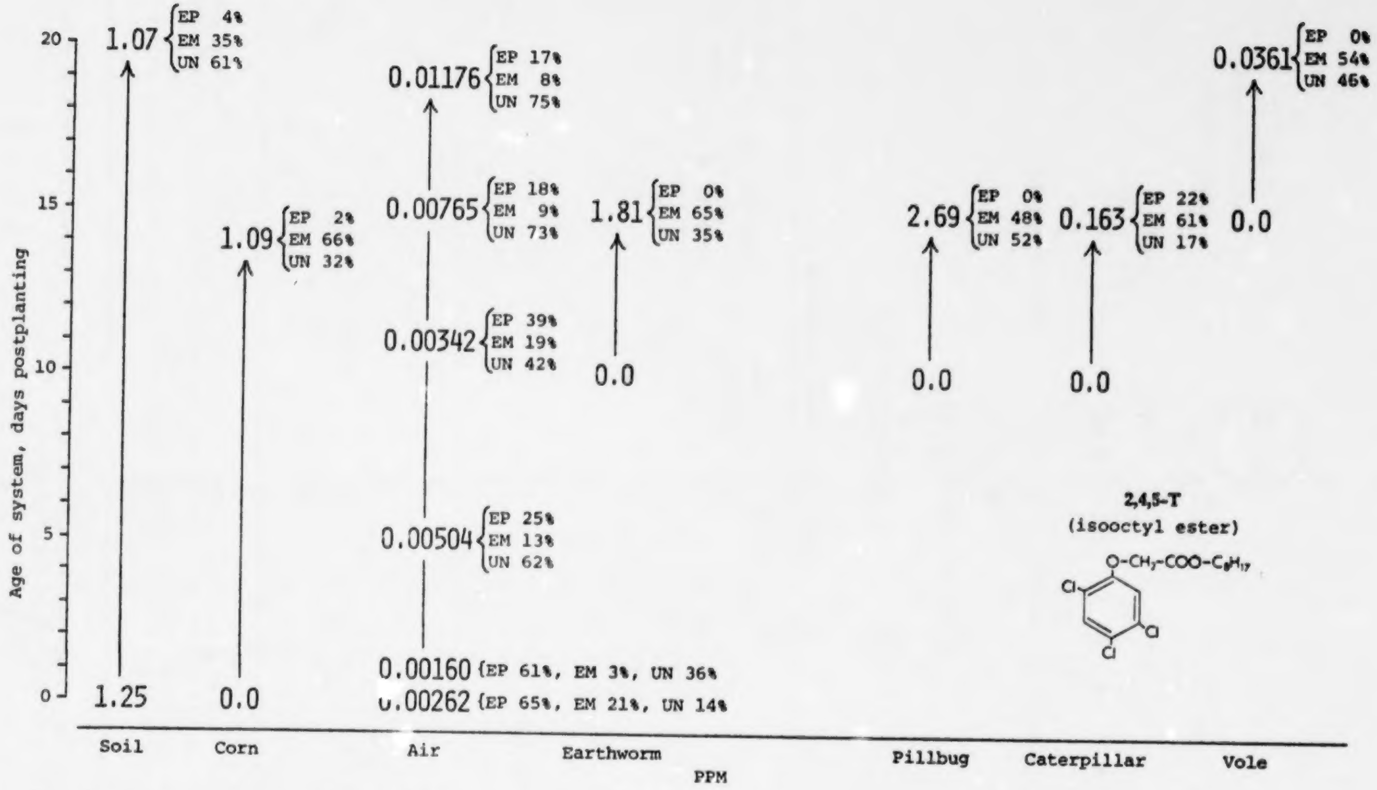


Fig. 77.—Summary of the fate of $[^{14}C]$2,4,5-T (isooctyl ester) in a soil-terrestrial model ecosystem. The total ^{14}C-residues are expressed as 2,4,5-T equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample. On day zero, the corn seeds were planted and the soil was treated with 2,4,5-T at one lb AI/acre. On days 10 and 15, the invertebrates and the vole were added, respectively.

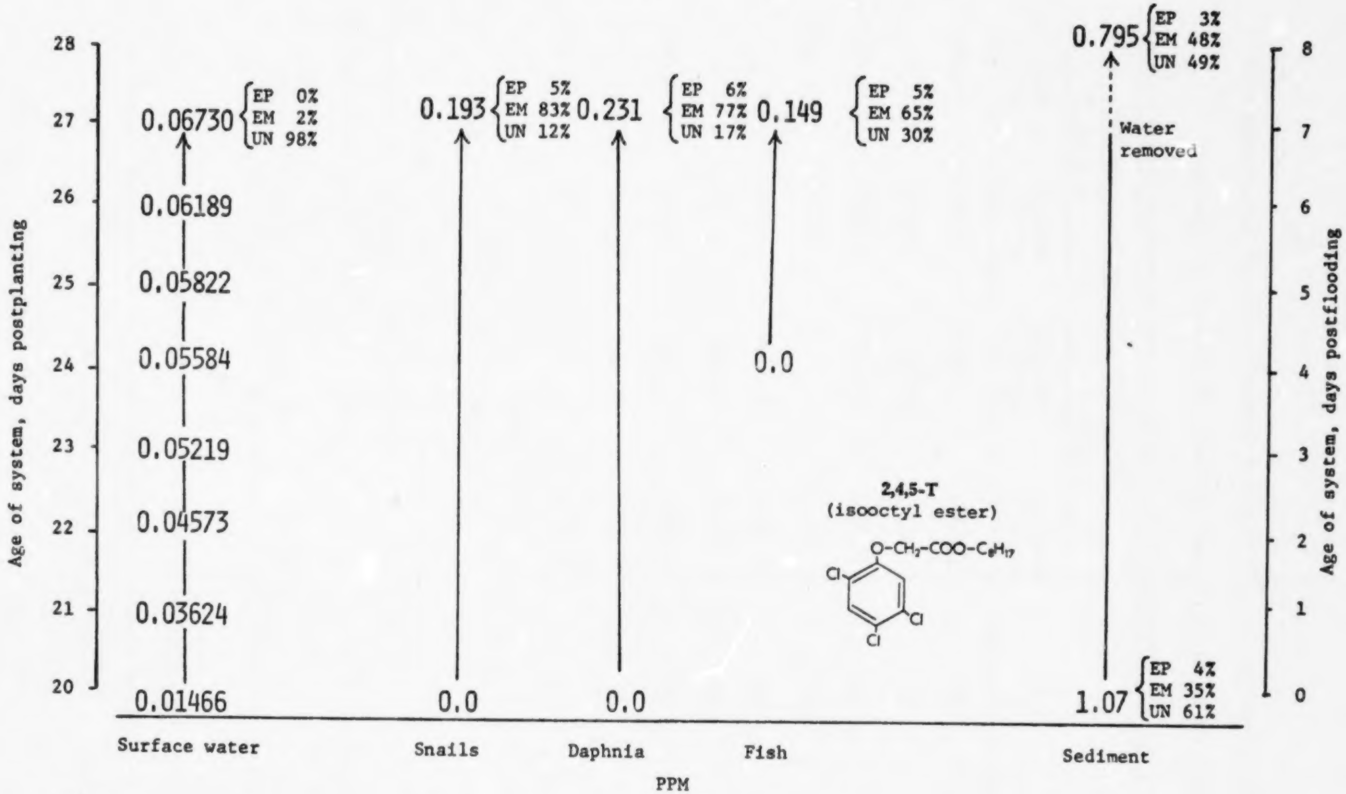


Fig. 78 .—Summary of the fate of $[^{14}C]$2,4,5-T in the aquatic phase; an extension of a soil-terrestrial model ecosystem (see Fig.). The barren terrestrial phase was flooded 20 days postplanting and snails, Daphnia, and mosquito larvae were added to the system; the fish were added 4 days later. The total ^{14}C-residues are expressed as 2,4,5-T equivalents, ppm (w/w), and their subdivisions are EP = extractable parent compound, EM = extractable metabolites of the parent compound, and UN = unextractable products remaining in the processed sample.

Table 141.–Concentrations of $[^{14}C]$2,4,5-T (isooctyl ester) and degradation products in the soil and sediment of a model ecosystem.

Compound	R_f[c]	2,4,5-T (ester) equivalents, ppm			
		Soil[a]		Sediment[b]	
		Acetone extract	Methanol extract[d]	Acetone extract	Methanol extract
2,4,5-T (ester)	.88	0.0321	0.0076	0.0224	0.0036
I[e]	.77	0.0043	0.0014	0.0033	-
II	.34	0.0207	0.0095	0.0300	0.0047
III	.28	-	-	0.0173	0.0019
IV	.11	0.0043	0.0010	0.0029	-
V	.08	0.0034	0.0008	0.0023	-
VI	.04	0.0039	0.0127	0.0360	0.0041
VII	.00	0.2265	0.0853	0.2354	0.0459
Extractable ^{14}C		0.2952	0.1183	0.3496	0.0602
Unextractable ^{14}C		0.6612		0.3855	
Total ^{14}C		1.0747		0.7953	
Sample wt (g)		100.0000		100.0000	

[a] Soil samples were taken 20 days after application of $[^{14}C]$2,4,5-T (isooctyl ester) to the soil.

[b] Sediment samples were taken 28 days after application of $[^{14}C]$2,4,5-T (isooctyl ester) to the soil, 8 days after flooding the ecosystem with water.

[c] Silica gel GF-254; n-hexane : acetone, 10:1 by volume.

[d] Methanol extract is from the sample previously extracted with acetone.

[e] Roman numerals = unknown compounds.

Table 142.- Concentrations of $[^{14}C]$2,4,5-T (isooctyl ester) and degradation products in corn[a] after a 14-day exposure in a model ecosystem.

Compound	R_f[c]	2,4,5-T (ester) equivalents, ppm[b] Root	Shoot	Entire plant
2,4,5-T (ester)	.88	0.029	0.003	0.019
I[d]	.42	0.031	0.008	0.022
II	.33	-	0.005	0.002
III	.17	0.006	-	0.004
IV	.13	0.002	-	0.001
V	.10	0.005	-	0.003
VI	.06	0.025	0.005	0.018
VII	.03	0.611	0.076	0.413
VIII	.00	0.372	0.073	0.261
Extractable ^{14}C		1.081	0.170	0.743
Unextractable ^{14}C		0.498	0.089	0.347
Total ^{14}C		1.579	0.259	1.090
Average Biosample wt (g)		1.740	1.024	2.764

[a] $[^{14}C]$2,4,5-T (isooctyl ester) was applied to the soil beneath each seed.

[b] The roots of 3 corn plants were combined and analyzed as an individual sample; the shoots were similarly processed.

[c] Silica gel GF-254; n-hexane : acetone, 10:1 by volume.

[d] Roman numerals = unknown compounds.

Table 143.-Concentrations of [^{14}C]2,4,5-T (isooctyl ester) and degradation products in the air[a/] from a model ecosystem.

Compound	R_f[c/]	2,4,5-T (ester) equivalents, ppm Trap 1[b/] Day 0	Day 1	Day 5	Day 11	Day 15	Day 19
2,4,5-T (ester)	.80	0.00170	0.00097	0.00127	0.00134	0.00136	0.00195
I[d/]	.32	0.00003	0.00003	0.00060	0.00045	0.00054	0.00076
II	.27	0.00001	-	-	-	-	-
III	.19	<0.00001	0.00001	-	-	-	-
IV	.14	0.00001	<0.00001	0.00002	0.00006	-	-
V	.09	<0.00001	<0.00001	0.00001	0.00003	0.00006	0.00006
VI	.04	0.00003	<0.00001	0.00001	0.00005	0.00003	0.00005
VII	.00	0.00046	0.00001	0.00003	0.00006	0.00003	0.00007
Total ^{14}C, Trap 1		0.00224	0.00102	0.00194	0.00199	0.00202	0.00289
Total ^{14}C, Trap 2[e/]		0.00038	0.00058	0.00310	0.00143	0.00563	0.00887
Sum ^{14}C, Traps 1 & 2		0.00262	0.00160	0.00504	0.00342	0.00765	0.01176
Sample wt (g)[f/]		108.00000	108.00000	108.00000	108.00000	108.00000	108.00000

[a/] Air was trapped for a 3-hour daylight period at a flow rate of 10 ml/sec on specified days after application of [^{14}C]2,4,5-T (isooctyl ester) to the soil.

[b/] Trap 1 was connected directly to the ecosystem container and contained 75 ml of acetonitrile as the trapping solvent; the trapping solvent was chromatographed.

[c/] Silica gel GF-254; n-hexane : acetone, 10:1 by volume.

[d/] Roman numerals = unknown compounds.

[e/] Trap 2 was connected in series to trap 1 and contained 75 ml of trapping solvent (ethanolamine : 2-methoxyethanol, 1:2 by volume); the trap 2 solvent was not chromatographed.

[f/] One liter of air was assumed to weigh 1 g.

Table 144–Concentrations of $[^{14}C]$2,4,5-T (isooctyl ester) and degradation products in invertebrates after a 5-day exposure in a model ecosystem.

Compound	R_f [a]	2,4,5-T (ester) equivalents, ppm *Armadillidium* [b] (pillbug)	*Estigmene* [c] (caterpillar)	*Lumbricus* [d] (earthworm)
2,4,5-T (ester)	.82	-	0.035	0.007
I [e]	.39	-	0.010	-
II	.27	0.009	0.022	0.052
III	.09	-	-	0.019
IV	.04	-	-	0.627
V	.02	-	-	0.197
VI	.00	1.284	0.068	0.287
Extractable ^{14}C		1.293	0.135	1.189
Unextractable ^{14}C		1.402	0.027	0.626
Total ^{14}C		2.695	0.163	1.815
Average biosample wt (g)		0.058	0.912	2.147

[a] Silica gel GF-254; n-hexane : acetone, 10:1 by volume.

[b] Three pillbugs were processed together; batch weight = 0.174 g.

[c] Three caterpillars were processed together; batch weight = 2.736 g.

[d] Only one earthworm was recovered from ecosystem and processed.

[e] Roman numerals = unknown compounds.

Table 145—Concentrations of $[^{14}C]$2,4,5-T (isooctyl ester) and degradation products in the prairie vole after a 5-day exposure in a model ecosystem.

Compound	R_f[a]	2,4,5-T (ester) equivalents, ppm							
		Remaining organs[b]	Skin	GI tract	Liver	Fat	Carcass	Brain	Body totals[c]
I[d]	.48	0.0017	-	0.0006	0.0003	0.0022	-	-	0.0003
II	.41	-	-	0.0019	0.0003	-	-	-	0.0003
III	.31	-	-	0.0031	0.0007	-	0.0007	-	0.0008
IV	.23	0.0012	0.0054	0.0018	0.0003	-	-	-	0.0012
V	.13	0.0025	-	0.0018	0.0003	0.0029	-	-	0.0005
VI	.06	-	-	0.0184	0.0012	-	-	-	0.0025
VII	.00	0.0411	0.0187	0.0127	0.0155	0.0082	0.0112	0.0083	0.0138
Extractable ^{14}C		0.0465	0.0241	0.0403	0.0186	0.0133	0.0119	0.0083	0.0194
Unextractable ^{14}C		0.0342	0.0425	0.0233	0.0122	0.0127	0.0073	0.0037	0.0167
Total ^{14}C		0.0807	0.0666	0.0636	0.0308	0.0260	0.0192	0.0120	0.0361
Biosample wt (g)		1.5449	4.3030	3.5239	1.5488	0.6983	12.5614	0.5371	-

a/ Silica gel GF-254; n-hexane : acetone, 10:1 by volume.

b/ Internal organs, other than those specified, were combined and processed as an individual sample.

c/ Body totals were calculated using live body weight (26.2900 g).

d/ Roman numerals = unknown compounds.

Table 146.-Relative affinities of 7 body-parts of the prairie vole[a] for $[^{14}C]$2,4,5-T (isooctyl ester) plus its metabolites, and comparisons with the relative masses of the body-parts.

Body-part (organs and tissues)	Residue wt in body-part as a % of total residue wt in entire body	Body-part wt as a % of entire body wt
Skin	30.19	17.41
Carcass[b]	25.43	50.82
GI tract	23.64	14.26
Liver	5.02	6.26
Fat	1.91	2.83
Brain	.68	2.18
Remaining organs[c]	13.14	6.25
	100.01	100.01

[a] Vole from a soil-terrestrial model ecosystem treated with $[^{14}C]$2,4,5-T (isooctyl ester).

[b] Carcass = the eviscerated body (the removed organs and tissues are listed above); it consists predominately of muscle and bone.

[c] The kidneys + adrenals, heart, lungs, mammary glands, ventral central neck gland, parotid glands and small amounts of fat tissue were nalyzed collectively.

Table 147.—Concentrations of [^{14}C]2,4,5-T (isooctyl ester) and degradation products in the water of a model ecosystem 7 days after flooding the ecosystem with water[a].

Compound	R_f[b]	2,4,5-T (ester) equivalents, ppm Surface water
I[c]	.39	0.00007
II	.26	0.00007
III	.11	0.00007
IV	.06	0.00022
V	.02	0.00048
VI	.00	0.00061
Extractable ^{14}C		0.00152
Unextractable ^{14}C[d]		0.06454
^{14}C loss during extraction		0.00124
Initial ^{14}C in water		0.06730
Sample volume (1)		1.00000

[a] Ecosystem was flooded with water 20 days after application of [^{14}C]2,4,5-T (isooctyl ester) to the soil.

[b] Silica gel GF-254; n-hexane : acetone, 10:1 by volume.

[c] Roman numerals = unknown compounds.

[d] The water, after ether extraction, was not subjected to the usual hydrolysis procedure.

Table 148.—Concentrations of $[^{14}C]$2,4,5-T (isooctyl ester) and degradation products in aquatic organisms in a model ecosystem flooded with water[a].

		2,4,5-T (ester) equivalents, ppm		
Compound	R_f[b]	*Gambusia*[c] (fish)	*Physa*[d] (snail)	*Daphnia*[e] (water flea)
I[f]	.80	0.004	-	-
2,4,5-T (ester)	.73	0.007	0.009	0.014
II	.40	0.002	-	-
III	.25	0.037	0.021	0.021
IV	.19	0.005	0.003	0.009
V	.11	0.003	0.008	0.002
VI	.07	0.001	0.006	0.001
VII	.05	0.017	0.029	0.005
VIII	.00	0.028	0.094	0.140
Extractable ^{14}C		0.104	0.170	0.192
Unextractable ^{14}C		0.045	0.023	0.040
Total ^{14}C		0.149	0.193	0.232
Average biosample wt (g)		0.233	0.168	0.567

[a] Ecosystem was flooded with water 20 days after application of $[^{14}C]$-2,4,5-T (isooctyl ester) to the soil.

[b] Silica gel GF-254; n-hexane : acetone, 10:1 by volume.

[c] Three fish were added 4 days after flooding the ecosystem; 2 fish (dead) were removed 5 hrs later and 1 fish (dead) 1 day later; three more fish were added 5 days after flooding the ecosystem; 1 fish (dead) was removed 15 hrs later and 2 fish (dead) 1 day later; the fish were processed individually or in pairs (as removed), and the results averaged.

[d] Snails were added on the day of flooding; 15 snails were removed 7 days later and processed as a batch; batch weight = 2.525 g.

[e] Daphnia were added on the day of flooding, removed 7 days later, and processed as a batch; many organisms constituted the biosample.

[f] Roman numerals = unknown compounds.

Table 149.Summary of substrate influence on the quantitative distribution of [^{14}C]aldrin plus its metabolites in terrestrial model ecosystems.

Age,[a] days	Ecosystem component	Total ^{14}C-metabolites expressed as aldrin equivalents, ppm						Average fate of aldrin in soil systems vs. vermiculite systems
		Vermiculite systems			Drummer loam soil systems			
		A	B	$\bar{x}$	A	B	$\bar{x}$	
20	Vermiculite (2.03[b])	0.954	0.809	0.882				58% loss
20	Soil (1.25[b])				1.24	1.28	1.26	0% loss
5	Atmosphere	45.7×10^{-3}	12.1×10^{-3}	28.9×10^{-3}	4.33×10^{-3}	2.09×10^{-3}	3.21×10^{-3}	89% less
6	Corn	8.795	9.217	9.006	1.509	1.050	1.280	86% less
10	Corn	5.819	4.758	5.289	1.023	0.495	0.759	86% less
14	Corn	7.771	8.332	8.051	0.700	0.743	0.721	91% less
15	Slug	2.056	3.099	2.578	0.513	0.267	0.391	85% less
15	Caterpillar	4.323	2.426	3.375	0.523	0.480	0.502	85% less
15	Earthworm	3.124	5.139	4.132	1.261		1.261	69% less
15	Pillbug	3.622	2.812	3.217	1.290	0.451	0.870	73% less
20	Vole	2.135	0.478	1.307	0.632	0.207	0.421	68% less
								$\bar{x}$ 81% less

[a] Post-planting (and post-dosing) age at the time of sampling for analysis.

[b] Initial concentration, ppm, in substrate; equal quantities of aldrin were added to the substrates of all of the systems at the time of planting, but the initial concentrations differ in soil and vermiculite due to their differences in density.

Table 150. Total ^{14}C-metabolites expressed as aldrin equivalents, ppm, in individual organisms of different species from four model ecosystems; two systems contained a vermiculite substrate and two contained a Drummer loam soil substrate; the statistics are the arithmetic mean ± standard error, and analysis of variance F values with significant differences indicated by an asterisk (factors are DL soil and vermiculite).

Vermiculite systems		Drummer loam soil systems	
A	B	A	B
CORN (entire plant)			
8.801	12.868	1.565	0.685
8.789	5.566	1.453	1.415
5.306	3.956	0.506	0.419
6.331	5.559	1.540	0.570
6.720	7.994	0.749	0.947
8.322	8.670	0.650	0.538
7.462±0.629	7.436±1.297	1.077±0.201	0.762±0.150
Between factors, $F_{0.001[1,2]}=1708$;** within factors, $F_{0.001[2,20]}=0.0466$			
SLUGS			
1.918	3.099	0.236	0.245
2.194		0.533	0.275
		0.720	0.282
2.056±0.138	(3.099)	0.513±0.126	0.267±0.011
Between factors, $F_{0.05[1,2]}=19.9$;* within factors, $F_{0.05[2,5]}=15.3$			
CATERPILLARS			
5.146	2.017	0.235	0.712
4.282	2.599	0.483	0.438
3.542	2.633	0.797	0.289
4.323±0.463	2.426±0.205	0.523±0.149	0.480±0.124
Between factors, $F_{0.10[1,2]}=9.04$;* $F_{0.10[2,8]}=12.4$*			
PILLBUGS			
4.570	2.956	1.207	0.663
3.757	2.669	1.376	0.238
2.539		1.238	
3.622±0.590	2.813±0.144	1.290±0.049	0.451±0.213
Between factors, $F_{0.10[1,2]}=16.8$;* within factors, $F_{0.10[2,6]}=2.19$			

Table 151. Total ^{14}C-metabolites expressed as aldrin equivalents, ppm, in duplicate corn samples at each of three postplanting ages (6, 10, and 14 days) from four different model ecosystems; two of the systems (VA and VB) contain a vermiculite substrate and two (SA and SB) contain a natural soil substrate.

Substrate Replicate Age Plant	PLANT x_i	AGES $\bar{X}\pm s$ n=2	REPLICATES $\bar{X}\pm s$ n=6	SUBSTRATES $\bar{X}\pm s$ n=12
VA 6-1	8.801	8.795±0.008	7.462±1.542	7.449±2.381 C.V. = 32%
VA 6-2	8.789			
VA10-1	5.306	5.819±0.725		
VA10-2	6.331			
VA14-1	6.720	7.771±1.486		
VA14-2	8.822			
VB 6-1	12.868	9.217±5.163	7.436±3.177	
VB 6-2	5.566			
VB10-1	3.956	4.758±1.133		
VB10-2	5.559			
VB14-1	7.994	8.332±0.478		
VB14-2	8.670			
SA 6-1	1.565	1.509±0.079	1.077±0.492	0.920±0.445 C.V. = 48%
SA 6-2	1.453			
SA10-1	0.506	1.023±0.731		
SA10-2	1.540			
SA14-1	0.749	0.700±0.070		
SA14-2	0.650			
SB 6-1	0.685	1.050±0.516	0.762±0.366	
SB 6-2	1.415			
SB10-1	0.419	0.495±0.107		
SB10-2	0.570			
SB14-1	0.947	0.743±0.289		
SB14-2	0.538			

C.V. = coefficient of variation, expressed as a percentage = $\frac{(100)s}{\bar{x}}$

Table 152. Ecosystems containing vermiculite: total ^{14}C-metabolites expressed as aldrin equivalents, ppm, in the individuals of various species, and the variation within individual samples.

		Ecosystem A						Summary of Systems A and B	
Age, days	Component	X_1	X_2	X_3	$\overline{X}$	s	C.V.(%)	s	C.V.(%)
6	Corn	8.801	8.789		8.795	0.008	0.097	0.008	0.097
10	Corn	5.306	6.331		5.819	0.725	12.5	0.195	5.74
14	Corn	6.720	8.822		7.771	1.486	19.1	0.203	7.21
15	Slug	1.918	2.194		2.056	0.195	9.48	0.356	9.48
15	Caterpillar	5.146	4.282	3.542	4.323	0.803	18.6	0.478	12.5
15	Pillbug	4.570	3.757	2.539	3.622	1.022	28.2	0.725	14.7
								0.803	18.6
								1.022	19.1
		Ecosystem B						1.133	23.8
								1.486	28.2
6	Corn	12.868	5.566		9.217	5.163	56.0	5.163	56.0
10	Corn	3.956	5.559		4.758	1.133	23.8		
14	Corn	7.994	8.670		8.332	0.478	5.74	Average C.V. within individual samples: 18%	
15	Slug	3.099							
15	Caterpillar	2.017	2.599	2.663	2.426	0.356	14.7		
15	Pillbug	2.956	2.669		2.813	0.203	7.21		

Table 153. Ecosystems containing Drummer loam soil: total ^{14}C-metabolites expressed as aldrin equivalents, ppm, in the individuals of various species, and the variation within individual samples.

		Ecosystem A						Summary of Systems A and B	
Age, days	Component	X_1	X_2	X_3	$\bar{X}$	s	C.V.(%)	s	C.V.(%)
6	Corn	1.565	1.453		1.509	0.079	5.25	0.020	5.25
10	Corn	0.506	1.540		1.023	0.731	71.5	0.070	6.55
14	Corn	0.749	0.650		0.700	0.070	10.0	0.079	7.36
15	Slug	0.286	0.533	0.720	0.513	0.218	42.4	0.085	10.0
15	Caterpillar	0.285	0.488	0.797	0.523	0.258	49.3	0.107	21.6
15	Earthworm	1.205	1.897	0.681	1.261	0.610	48.4	0.215	38.9
15	Pillbug	1.207	1.376	1.288	1.290	0.085	6.55	0.218	42.4
								0.258	44.7
								0.289	48.4
		Ecosystem B						0.301	49.1
								0.516	49.3
6	Corn	0.685	1.415		1.050	0.516	49.1	0.610	66.6
10	Corn	0.419	0.570		0.495	0.107	21.6	0.731	71.5
14	Corn	0.947	0.538		0.743	0.289	38.9		
15	Slug	0.245	0.275	0.282	0.267	0.020	7.36	Average C.V.	
15	Caterpillar	0.712	0.438	0.289	0.480	0.215	44.7	within indi-	
15	Pillbug	0.663	0.238		0.451	0.301	66.6	vidual samples:	
									36%

Table 154.-Pesticides in the aquatic phase subsequent to the terrestrial phase[a].

Parent compound	Total ^{14}C-pesticidal residue, ppm (with % parent compound in parentheses)			
	Accumulation in water[b] 7 days after flooding		Mean accumulation in fish and snails[c]	
		FUNGICIDES		
PCP	0.00848	(8)	2.14	(23)
PCNB	0.00878	(2)	1.66	(16)
HCB	0.00173	(47)	0.838	(48)
Captan	0.00294	(0.1)	0.602	(6)
		HERBICIDES		
Trifluralin (soybeans)	0.00913	(0)	0.315	(21)****
2,4,5-T (isooctyl ester)	0.06730	(0)	0.171	(5)***
Simazine	0.05860	(80)	0.170	(62)**
		INSECTICIDES		
Dieldrin (no crop)	0.00390	(40)	8.16	(94)
Parathion[d]	0.00741	(4)	0.787	(3)
Methyl parathion[d]	0.00667	(1)	0.713	(8)
Phorate	0.04710	(0.1)	0.377	(7)*
		VARIABLE SOIL/CROP (COMPARE ABOVE)		
Dieldrin (vermiculite)	0.02200	(41)	66.4	(91)
Phorate (loamy sand)	0.08320	(0.1)	0.796	(6)**
HCB (soybeans)	0.00117	(42)	1.59	(57)

[a] Except where indicated, all systems contained silty clay loam soil and corn.

[b] The mass of water was ca. 1.75 x greater than the mass of soil.

[c] Fish were exposed for 3 days, unless they died earlier, and snails for 7 days.

[d] The parathions were applied to corn foliage 10 days prior to flooding, all others were applied to soil 20 days prior to flooding.

* Asterisks demark those residues that were lethal to fish; the more numerous the asterisks, the more rapid the kill.

Table 155.-Transfer of pesticides to surface water subsequent to their exposure to a terrestrial environment: the total ^{14}C-pesticidal residue in water seven days post-flooding, expressed as a percent of the initial pesticide application

Fungicides		Herbicides		Insecticides	
PCNB	1.23 %	2,4,5-T (iso-octyl ester)	9.42 %	Phorate	6.60 %
PCP	1.19 %	Simazine	8.20 %	Parathion	1.04 %*
Captan	0.412 %	Trifluralin	1.28 %	Me. parathion	0.934 %*
HCB	0.242 %			Dieldrin	0.546 %

* Applied to corn foliage 10 days prior to flooding; all of the other compounds were applied to soil (silty clay loam) 20 days prior to flooding.

Table 156.-A synopsis of the differences in the terrestrial environmental fates of phorate as induced by varying the type of soil[a]

Parent compound	Total ^{14}C-insecticidal residue	
	Persistence in soil 20 days after application[b]	Mean accumulation in terrestrial animals[c]
Phorate in S.C.L.	61% (1)[d]	0.457 ppm (3)
Phorate in L.S.	35% (1)	1.54 ppm (2)

[a] S.C.L. = silty clay loam soil; L.S. = loamy sand.
[b] Percent of the applied dose.
[c] Five species exposed for five days.
[d] Each value in parentheses is the percent parent compound in the total residue; it describes the parent compound's resistance to degradation.

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Table 157.-A synopsis of the differences in the terrestrial environmental fates of aldrin as induced by varying the type of soil[a]

Parent compound	Total ^{14}C-insecticidal residue	
	Persistence in soil 20 days after application[b]	Mean accumulation in terrestrial animals[c]
Aldrin in S.C.L.	ca. 100% (67)[d]	0.689 ppm (6)
Aldrin in vermic.	42% (14)	2.92 ppm (7)

[a] S.C.L. = silty clay loam soil; vermic. = vermiculite.
[b] Percent of the applied dose.
[c] Five species exposed for five days.
[d] Each value in parentheses is the percent parent compound in the total residue; it describes the parent compound's resistance to degradation.

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Table 158.-A synopsis of the differences in the terrestrial environmental fates of HCB[a] as induced by varying the type of crop

Parent compound	Total ^{14}C-fungicidal residue	
	Persistence in soil 20 days after application[b]	Mean accumulation in terrestrial animals[c]
HCB (soybeans)	74% (96)[d]	1.51 ppm (85)
HCB (corn)	67% (95)	1.63 ppm (83)

[a] Hexachlorobenzene was applied to silty clay loam soil, not the crop.
[b] Percent of the applied dose.
[c] Five species exposed for five days.
[d] Each value in parentheses is the percent parent compound in the total residue; it describes the parent compound's resistance to degradation.

Table 159.-INSECTICIDES applied to Vermiculite: a synopsis and differentiation of their terrestrial environmental fates

Parent compound	Total ^{14}C-insecticidal residue	
	Persistence in vermiculite 20 days after application[a]	Mean accumulation in terrestrial animals[b]
Dieldrin	68% (86)[c]	3.65 ppm (70)
Aldrin	42% (14)	2.92 ppm (7)
Fonofos	9% (8)	0.571 ppm (1)

a/ Percent of applied dose.
b/ Five species exposed for five days (only caterpillar and vole data available for fonofos).
c/ Each value in parentheses is the percent parent compound in the total residue; it describes the parent compound's resistance to degradation.

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Table 160.-INSECTICIDES applied to Corn growing in Silty Clay Loam Soil: a synopsis and differentiation of their terrestrial environmental fates

Parent compound	Total ^{14}C-insecticidal residue	
	Accumulation in soil 10 days after application[a]	Mean accumulation in terrestrial animals[b]
Parathion	0.577 ppm (18)[c]	5.42 ppm (31)
Methyl parathion	0.398 ppm (4)	2.72 ppm (4)

a/ Maximum value possible in soil = 1.25 ppm.
b/ Five species exposed for five days.
c/ Each value in parentheses is the percent parent compound in the total residue; it describes the parent compound's resistance to degradation.

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Table 161.-INSECTICIDES applied to Corn growing in Vermiculite: a synopsis and differentiation of their terrestrial environmental fates

Parent compound	Total ^{14}C-insecticidal residue	
	Accumulation in vermiculite 10 days after application[a]	Mean accumulation in terrestrial animals[b]
DDT	1.73 ppm (65)[c]	22.3 ppm (39)
Methoxychlor	1.44 ppm (62)	3.03 ppm (26)

a/ Maximum value possible in vermiculite = 2.08 ppm.
b/ Five species exposed for five days.
c/ Each value in parentheses is the percent parent compound in the total residue; it describes the parent compound's resistance to degradation.

Table 162.-FUNGICIDES applied to Silty Clay Loam Soil: a synopsis and differentiation of their terrestrial environmental fates

Parent compound	Total ^{14}C-fungicidal residue	
	Persistence in soil 20 days after application[a]	Mean accumulation in terrestrial animals[b]
HCB	67% (95)[c]	1.63 ppm (83)
PCNB	64% (43)	1.34 ppm (19)
PCP	48% (19)	0.672 ppm (15)
Captan	13% (1)	0.228 ppm (12)

[a] Percent of the applied dose.

[b] Five species exposed for five days.

[c] Each value in parentheses is the percent parent compound in the total residue; it describes the parent compound's resistance to degradation.

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Table 163.-HERBICIDES applied to Silty Clay Loam Soil: a synopsis and differentiation of their terrestrial environmental fates

Parent compound	Total ^{14}C-herbicidal residue	
	Persistence in soil 20 days after application[a]	Mean accumulation in terrestrial animals[b]
Simazine	ca. 100% (70)[c]	1.86 ppm (41)
Trifluralin	78% (79)	1.36 ppm (44)
2,4,5-T isooctyl ester	74% (4)	1.17 ppm (5)

[a] Percent of the applied dose.

[b] Four species (no slugs) exposed for five days.

[c] Each value in parentheses is the percent parent compound in the total residue; it describes the parent compound's resistance to degradation.

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Table 164.-INSECTICIDES applied to Silty Clay Loam Soil: a synopsis and differentiation of their terrestrial environmental fates

Parent compound	Total ^{14}C-insecticidal residue	
	Persistence in soil 20 days after application[a]	Mean accumulation in terrestrial animals[b]
Aldrin	ca. 100% (67)[c]	0.689 ppm (6)
Phorate	61% (1)	0.457 ppm (3)

[a] Percent of the applied dose.

[b] Five species exposed for five days.

[c] Each value in parentheses is the percent parent compound in the total residue; it describes the parent compound's resistance to degradation.

Table 165.—Grand summary: fate of ^{14}C-fungicides in terrestrial-modular model ecosystems[a/]

Ecosystem component and postplanting age at analysis (days)	Total ^{14}C-fungicidal residues (ppm)				Extractable parent ^{14}C-fungicidal compounds (ppm)				Resistance to degradation (% of extractable parent compound present in total residue)			
	HCB	PCNB	PCP	Captan	HCB	PCNB	PCP	Captan	HCB	PCNB	PCP	Captan
Substrate (20)	0.949	0.858	0.634	0.165	0.904	0.369	0.119	0.002	95.26	43.01	18.77	1.09
Air (5)[b/]	0.014	0.017	0.078	0.094								
Corn (14)	2.64	9.25	6.30	0.396	1.36	1.08	1.01	0.004	51.52	11.68	16.03	1.01
Earthworm (15)	0.584	1.39	0.551	0.181	0.530	0.146	0.046	0.0	90.75	10.50	8.35	0.0
Slug (15)	0.228	0.441	0.212	0.069	0.156	0.042	0.035	0.028	68.42	9.52	16.51	40.58
Pillbug (15)	4.09	1.77	0.618	0.470	3.85	0.511	0.022	0.053	94.13	28.87	3.56	11.28
Caterpillar (15)	0.347	2.44	1.45	0.299	0.286	0.973	0.541	0.019	82.42	39.88	37.31	6.35
Vole (20)	2.88	0.677	0.530	0.119	2.27	0.051	0.037	0.002	78.82	7.53	6.98	1.68
Water (27)	0.0017	0.009	0.008	0.003	0.0008	0.0002	0.001	<0.0001	47.06	1.71	8.14	0.10
Sediment (28)	0.818	...	...	...	0.701	...	...	...	85.70	...	...	...
Snail (27)	0.546	1.60	2.52	0.825	0.319	0.350	0.046	0.048	58.42	21.88	1.83	5.82
Fish (27)	1.13	1.72	1.76	0.378	0.420	0.171	0.779	0.021	37.17	9.94	44.26	5.56

[a/] Ecosystems contained Drummer silty clay loam soil; ^{14}C-fungicides were applied to the soil on Day 0.

[b/] Total ^{14}C-fungicidal residues only; percent extractable parent compound was not determined.

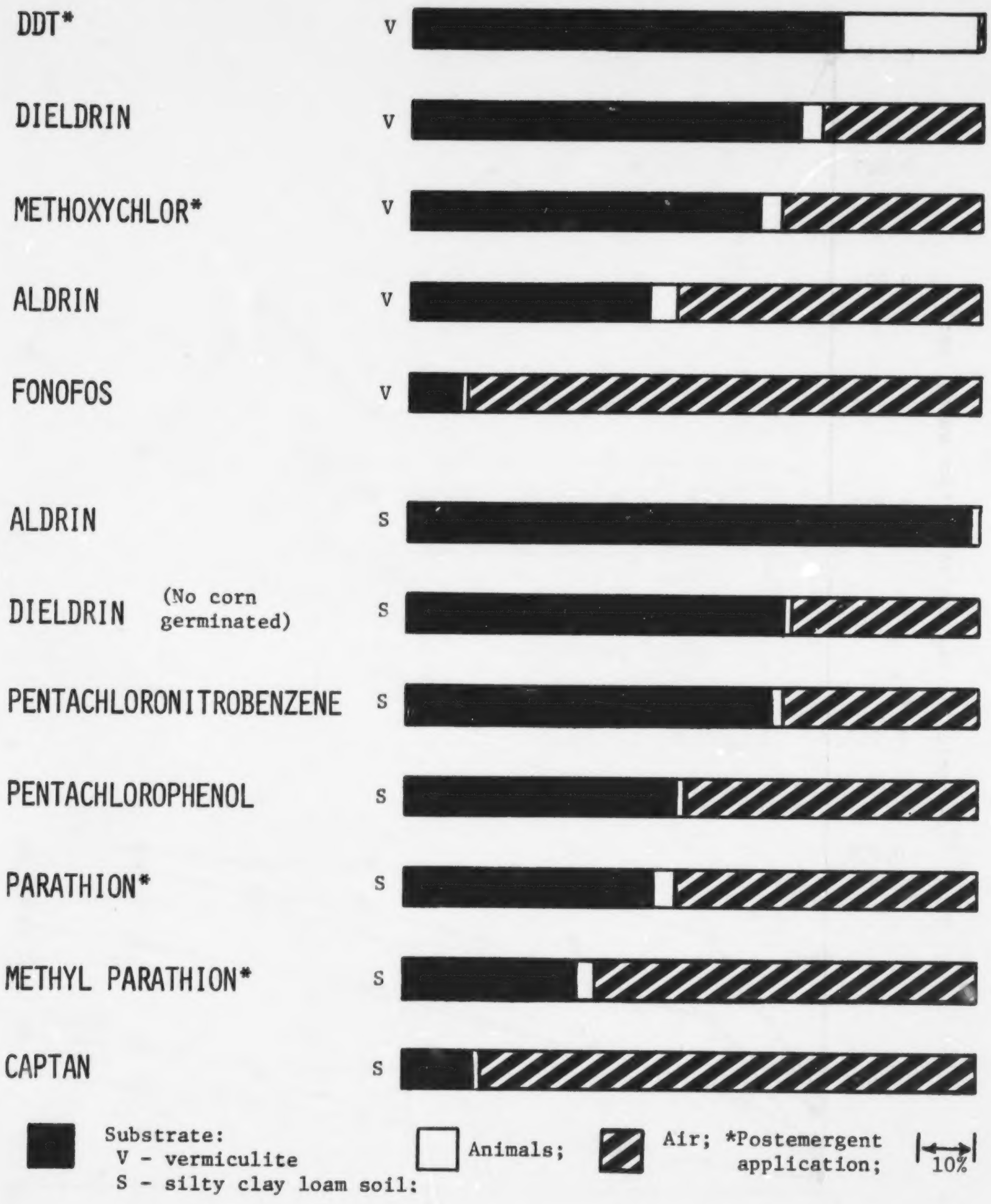
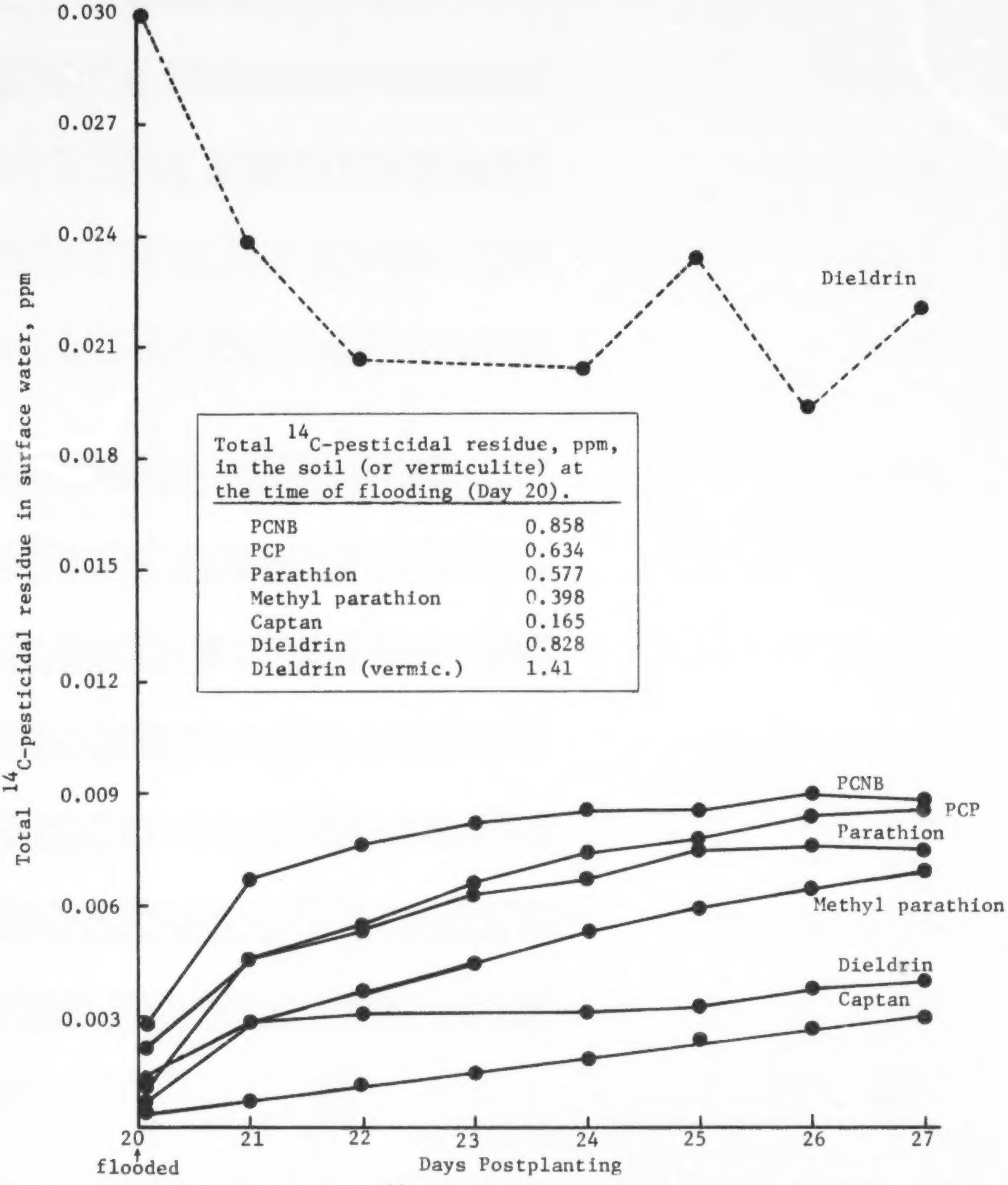


Fig. 79 .—Environmental distributions of the total ^{14}C-pesticidal residues (% of the applied dose) at the termination of the terrestrial phase of various model ecosystems dosed with a given pesticide. The plants, having been consumed and/or demolished by the animals, are not present as an entity at the termination of the system. (Calculations and more detailed distributions are presented in the text.)



Total ^{14}C-pesticidal residue, ppm, in the soil (or vermiculite) at the time of flooding (Day 20).

PCNB	0.858
PCP	0.634
Parathion	0.577
Methyl parathion	0.398
Captan	0.165
Dieldrin	0.828
Dieldrin (vermic.)	1.41

Fig. 80.—Translocations of total ^{14}C-pesticidal residues from soil (or vermiculite) to water. Solid lines: substrate was silty clay loam soil; dotted line: substrate was vermiculite. All systems were treated initially with the same absolute quantity of a given pesticide which in soil = 1.25 ppm, but in vermiculite = 2.08 ppm. The two parathions were applied initially to crop foliage, instead of substrate. No crop grew in the dieldrin-soil system.

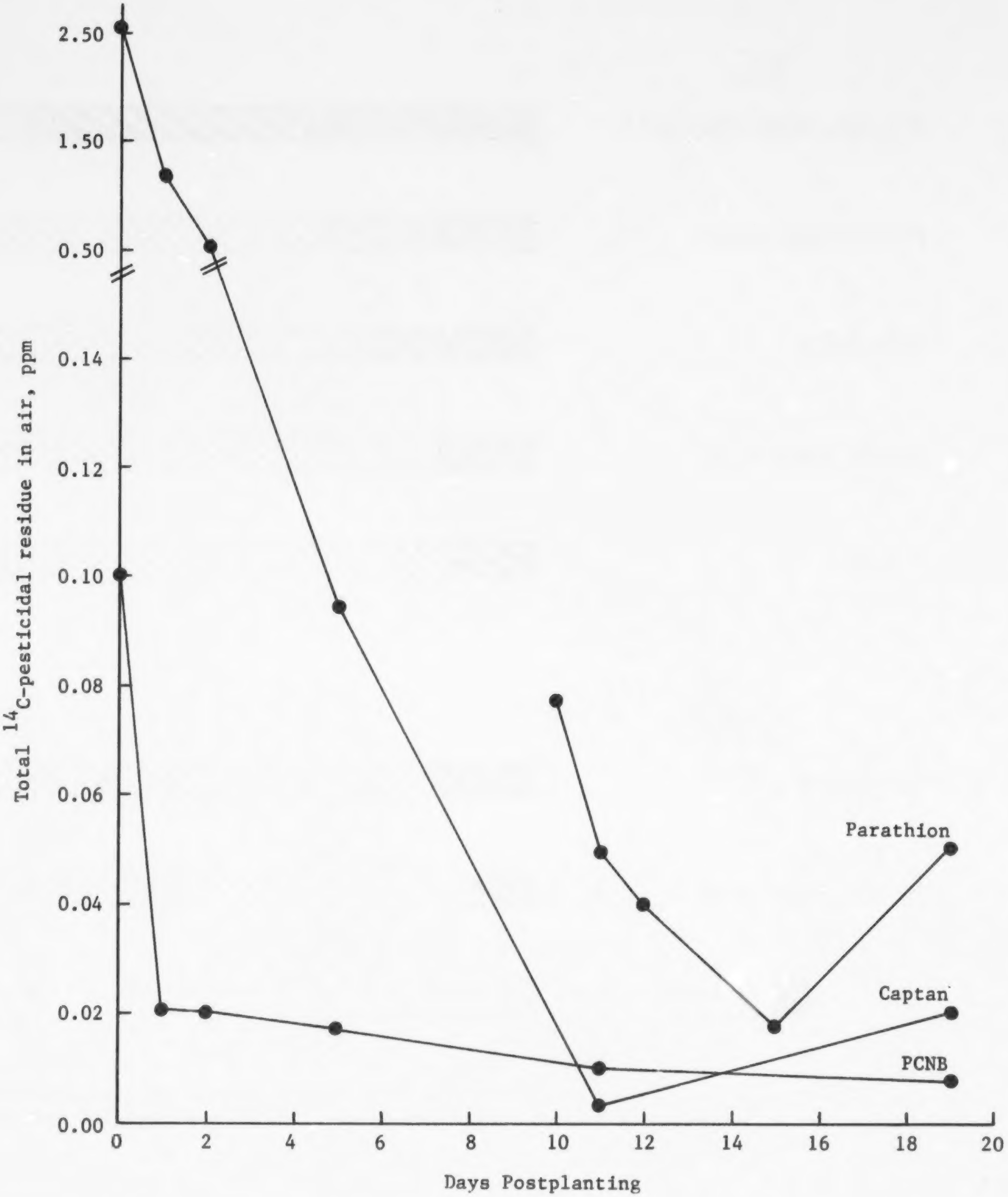


Fig. 81. —Translocations of total ^{14}C-pesticidal residues from soil to air during 3-hour daylight trapping periods. In the PCNB and captan systems, pesticide was applied to the soil on Day 0 (equivalent to 1.25 ppm). In the parathion system, pesticide was applied to corn foliage on Day 10.

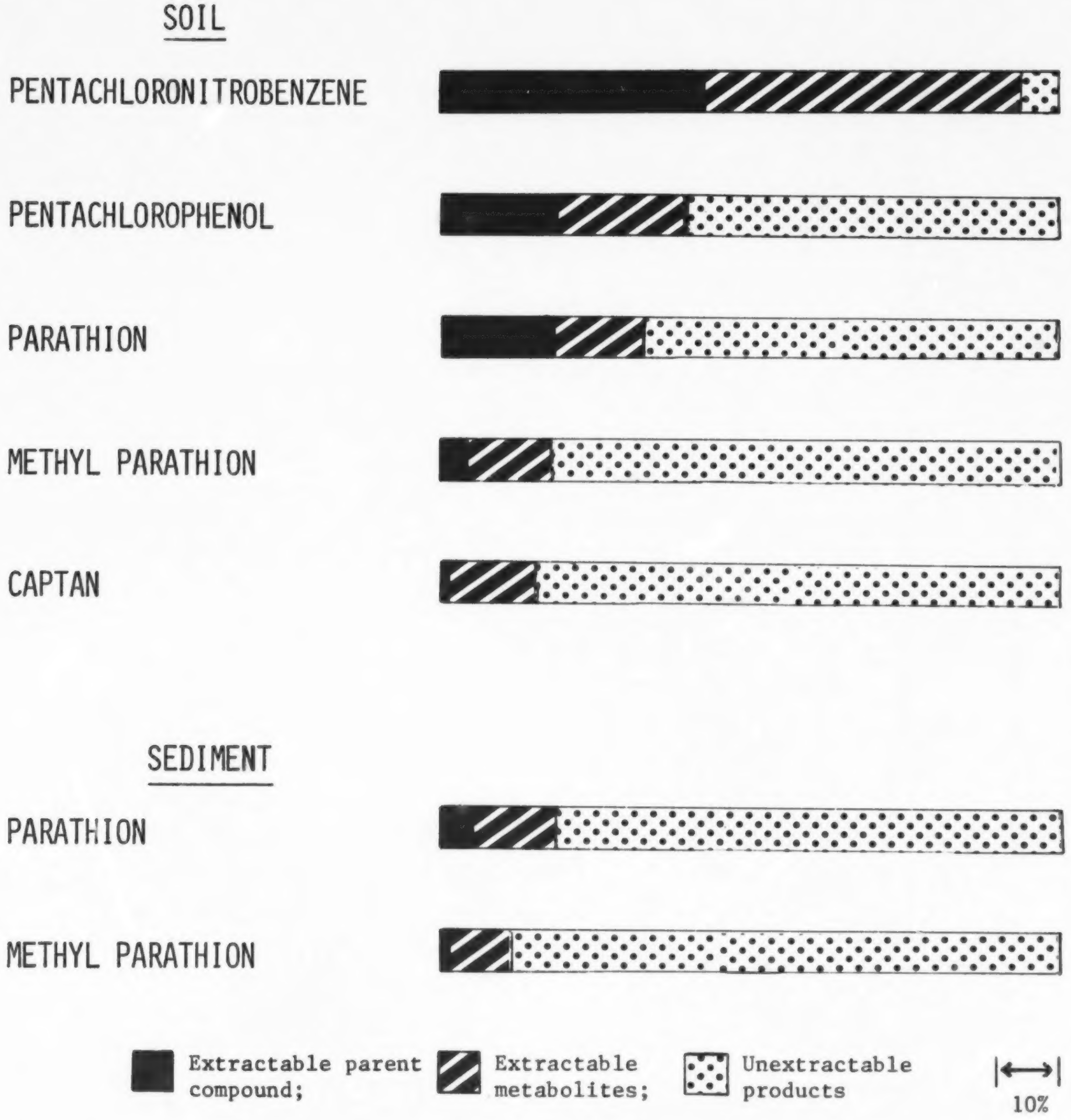


Fig. 82.— Proportions (%) of extractable parent compound, extractable metabolites, and unextractable products detected in the total ^{14}C-pesticidal residues in soil and sediment.

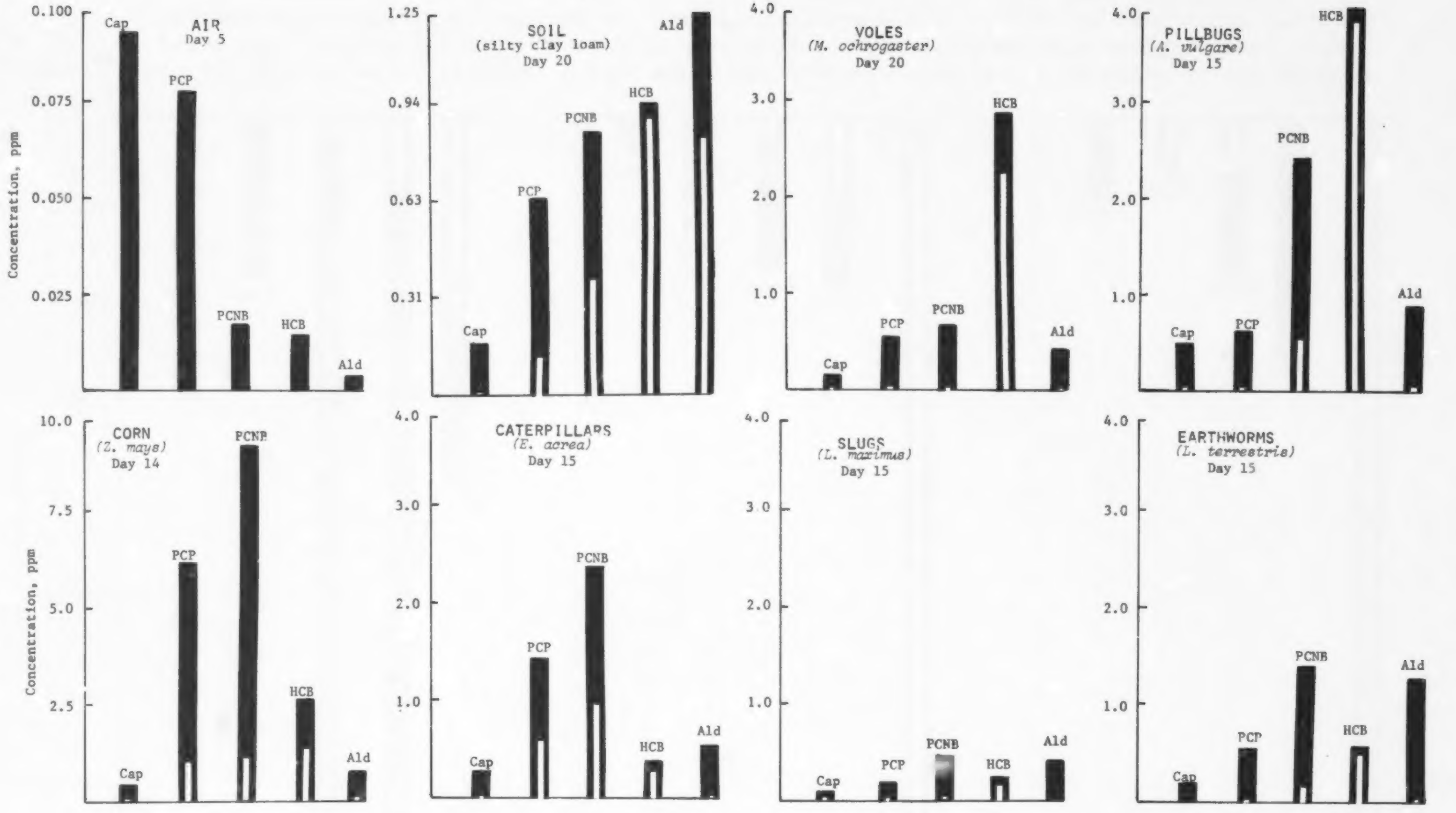


Fig. 83.—Total ^{14}C-pesticidal residues (black bars) and parent compounds (white bars) in the components of terrestrial model ecosystems at the indicated postplanting periods. The silty clay loam soil in each system was treated at planting with a single pesticide at a rate simulating one lb AI/acre. Invertebrate animals were added to the systems at Day 10, and the voles at Day 15. All animals were analyzed after a 5-day exposure within the systems, and the plants after 14 days.

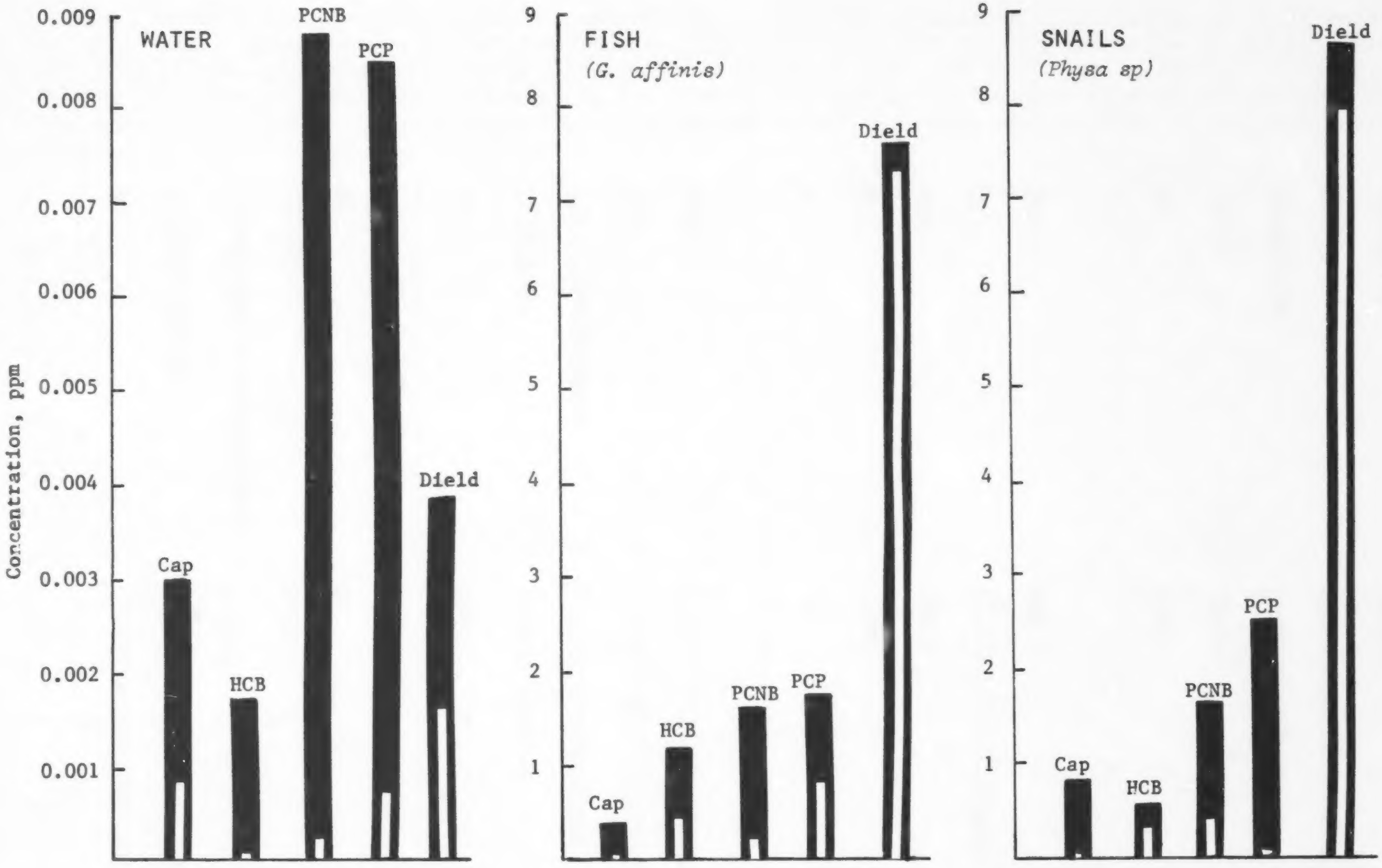


Fig. 84 .— Total ^{14}C-pesticidal residues (black bars) and parent compounds (white bars) in the aquatic phase of a soil-terrestrial model ecosystem treated with $[^{14}C]$dieldrin compared with those treated with fungicides. The barren terrestrial phases were flooded 20 days after dosing the soils. The snails were added at the time of flooding, and the fish were added 4 days later; water, fish and snails were analyzed 7 days postflooding.

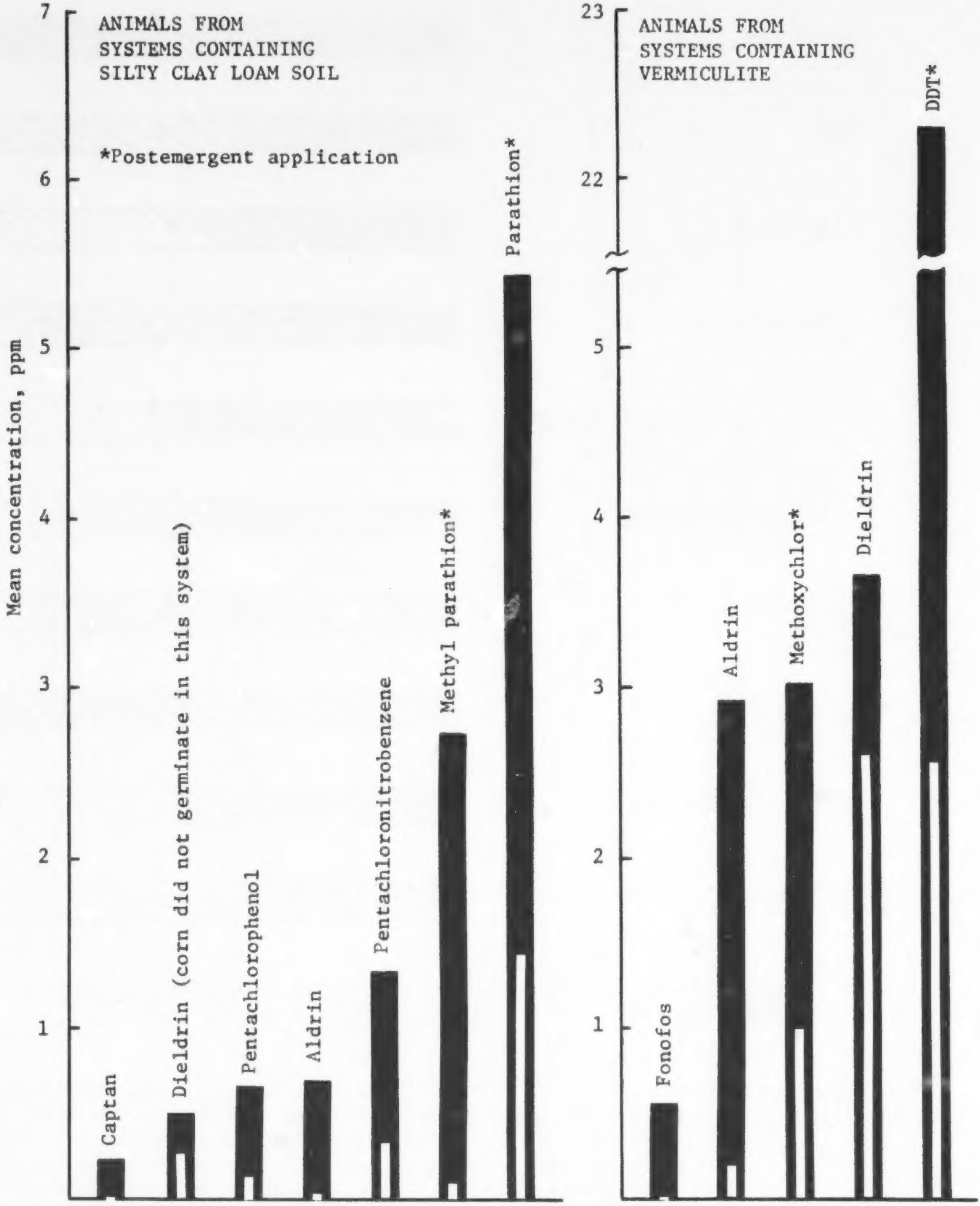


Fig.85 .—Accumulations of total ^{14}C-pesticidal residues (black bars) and parent compounds (white bars) in terrestrial animals as averaged over 5 species (earthworms, slugs, pillbugs, caterpillars, and voles) from model ecosystems containing either a vermiculite substrate or a silty clay loam soil. The animals were analyzed after a 5-day exposure within a given model ecosystem. Each system was dosed with a single pesticide at a rate simulating one lb AI/acre; the mode of application was either preemergent to substrate or postemergent to foliage, as indicated.

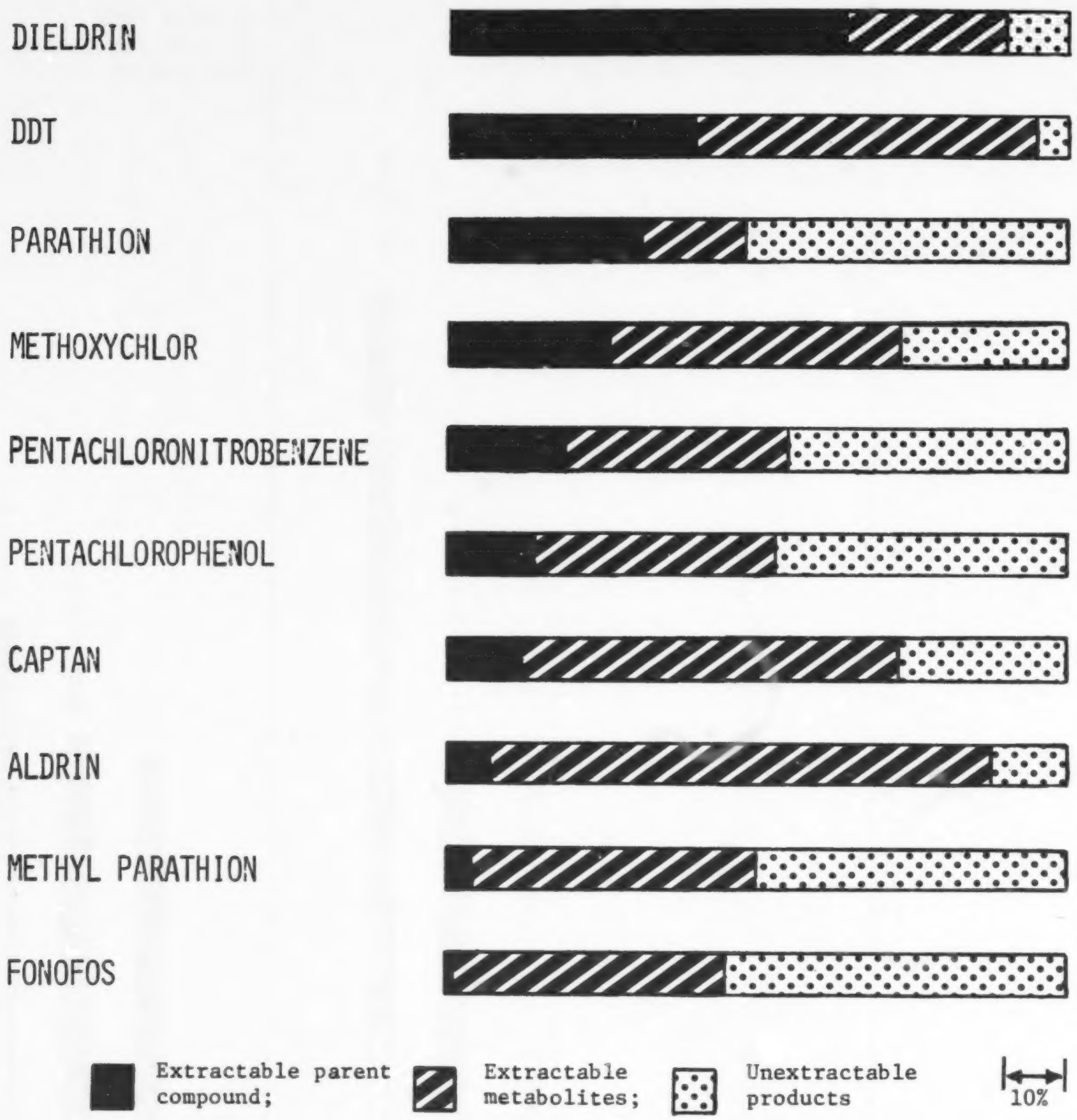


Fig. 86 .—Mean proportions (%) of extractable parent compound, extractable metabolites, and unextractable products detected in the total ^{14}C-pesticidal residues in terrestrial animals as averaged over 5 species (earthworms, slugs, pillbugs, caterpillars, and voles) from terrestrial model ecosystems; only the dieldrin residue was predominately parent compound. (Degradation within each species and the nature of the metabolites is described in the text.)

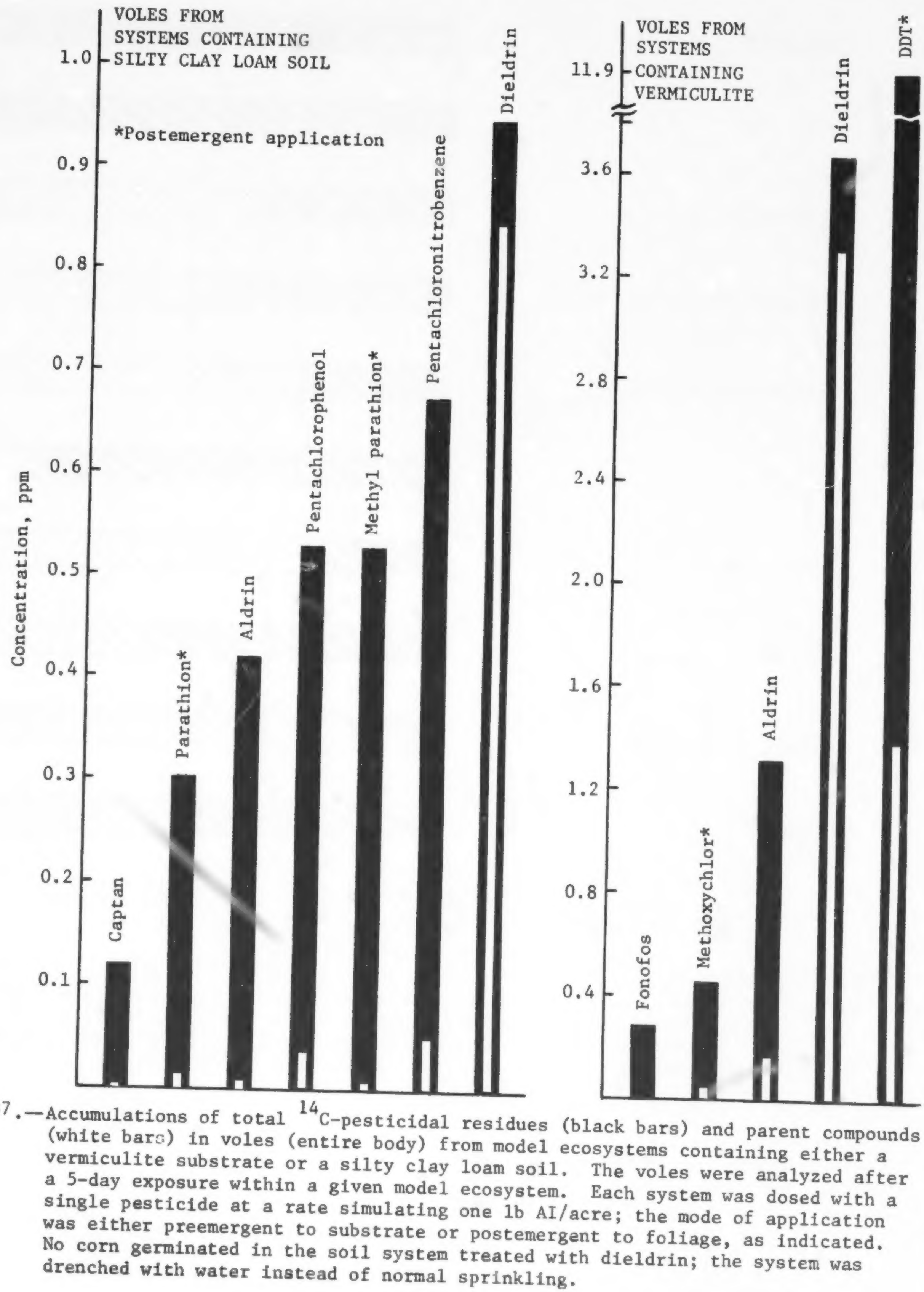


Fig. 87.—Accumulations of total ^{14}C-pesticidal residues (black bars) and parent compounds (white bars) in voles (entire body) from model ecosystems containing either a vermiculite substrate or a silty clay loam soil. The voles were analyzed after a 5-day exposure within a given model ecosystem. Each system was dosed with a single pesticide at a rate simulating one lb AI/acre; the mode of application was either preemergent to substrate or postemergent to foliage, as indicated. No corn germinated in the soil system treated with dieldrin; the system was drenched with water instead of normal sprinkling.

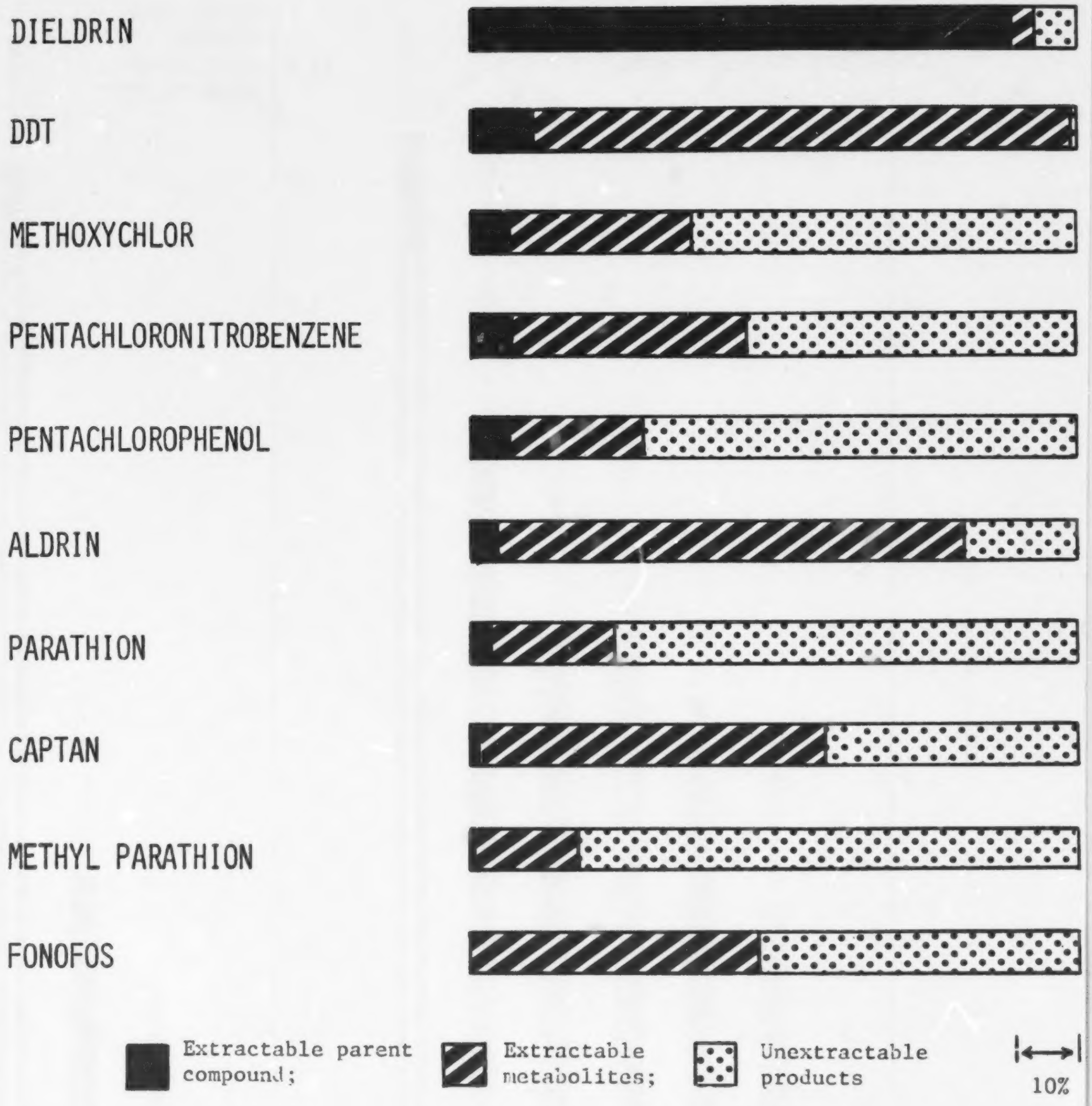


Fig. 88 .— Proportions (%) of extractable parent compound, extractable metabolites, and unextractable products detected in the total ^{14}C-pesticidal residues in the entire vole body. (Degradation within individual vole organs and the nature of the metabolites is described in the text.)

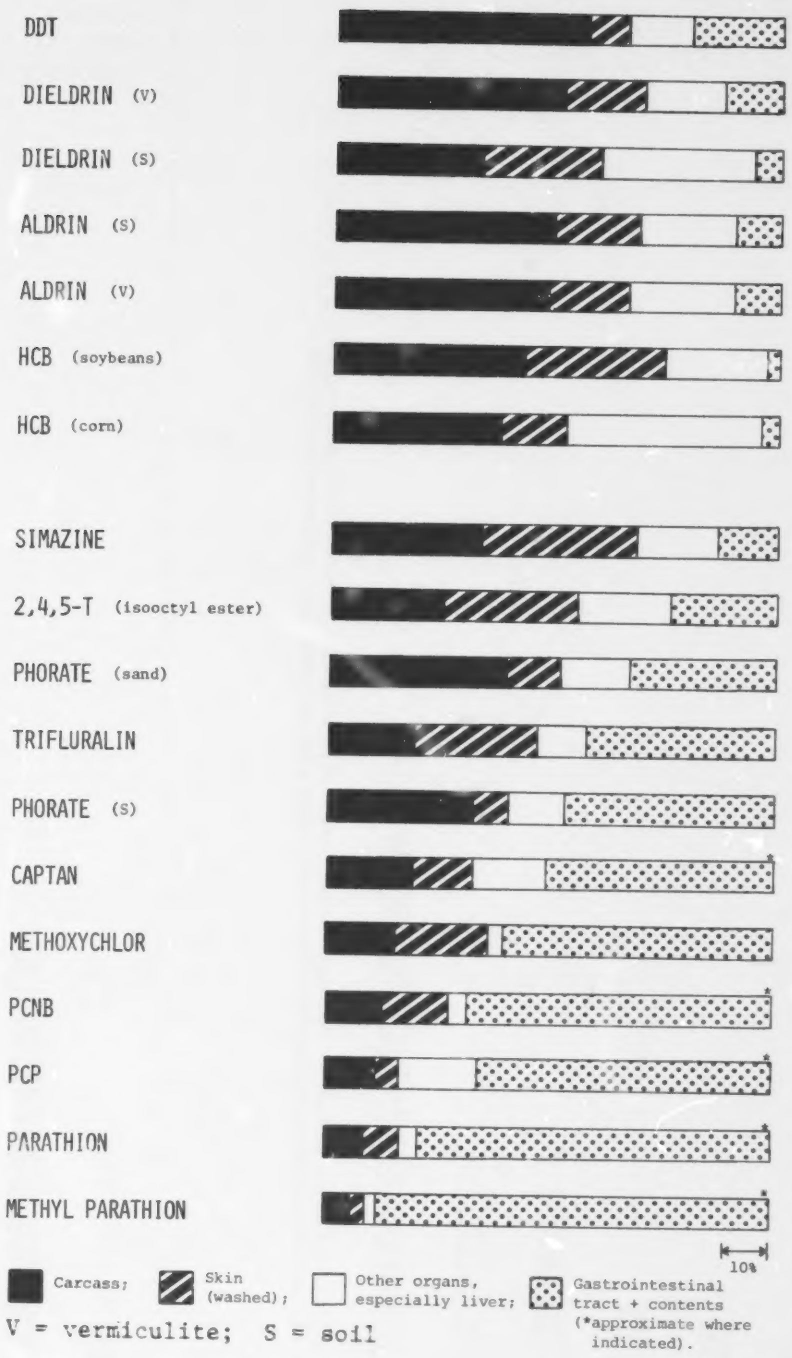


Fig 89.—Proportions (%) of the total ^{14}C-pesticidal residue (µg) detected in the entire vole located in various organs. These are distributions of actual quantities, not concentrations. The carcass is the body minus its viscera and skin; it consists predominately of muscle and bone. (Detailed distributions are described in the text and are compared with the relative masses of the organs.)

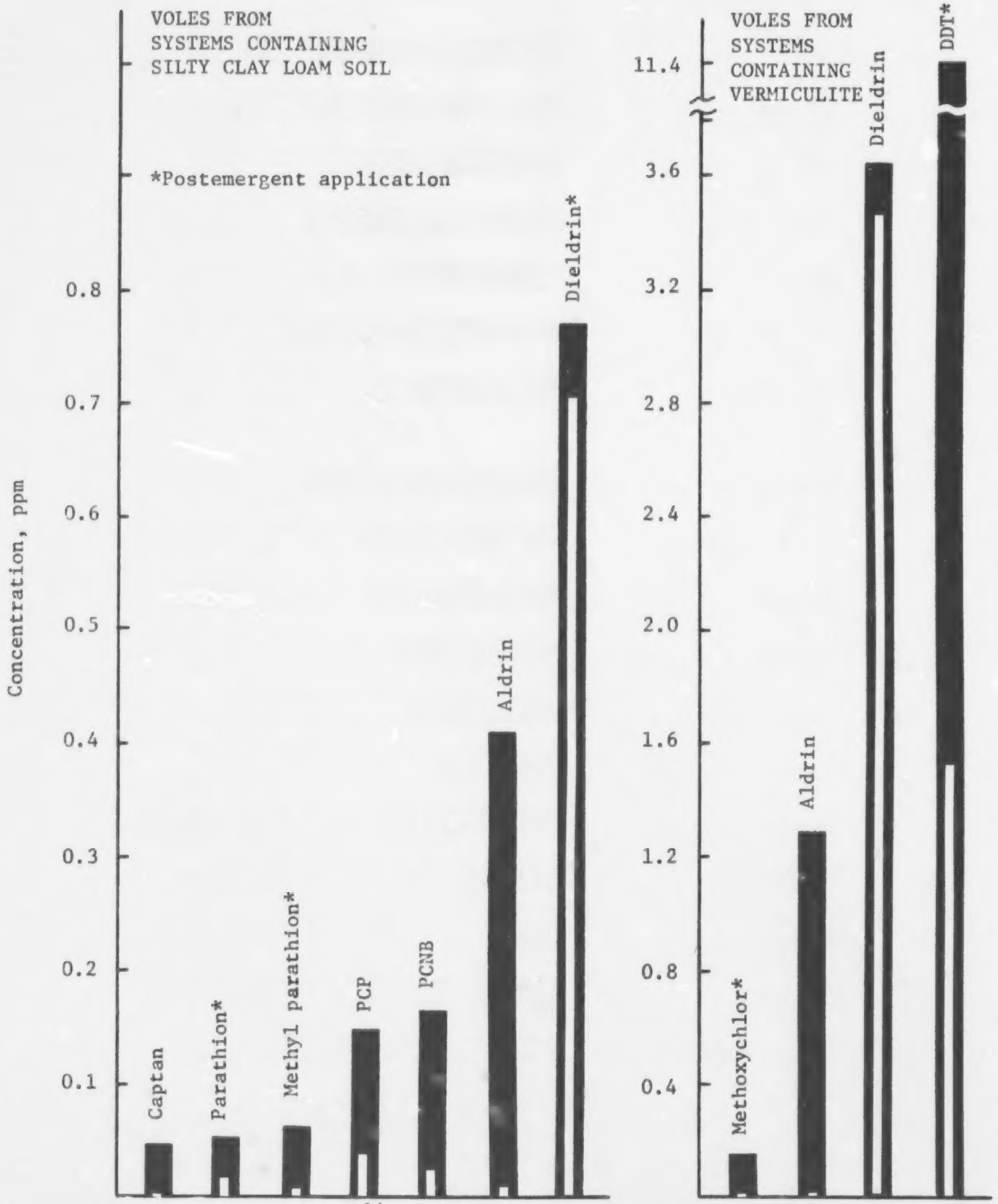


Fig. 90.—Accumulations of total ^{14}C-pesticidal residues (black bars) and parent compounds (white bars) in voles (carcass) from model ecosystems containing either a vermiculite substrate or a silty clay loam soil. The voles were analyzed after a 5-day exposure within a given model ecosystem. Each system was dosed with a single pesticide at a rate simulating one lb AI/acre; the mode of application was either preemergent to substrate or postemergent to foliage, as indicated. No corn germinated in the soil system treated with dieldrin; the system was drenched with water instead of the normal sprinklin

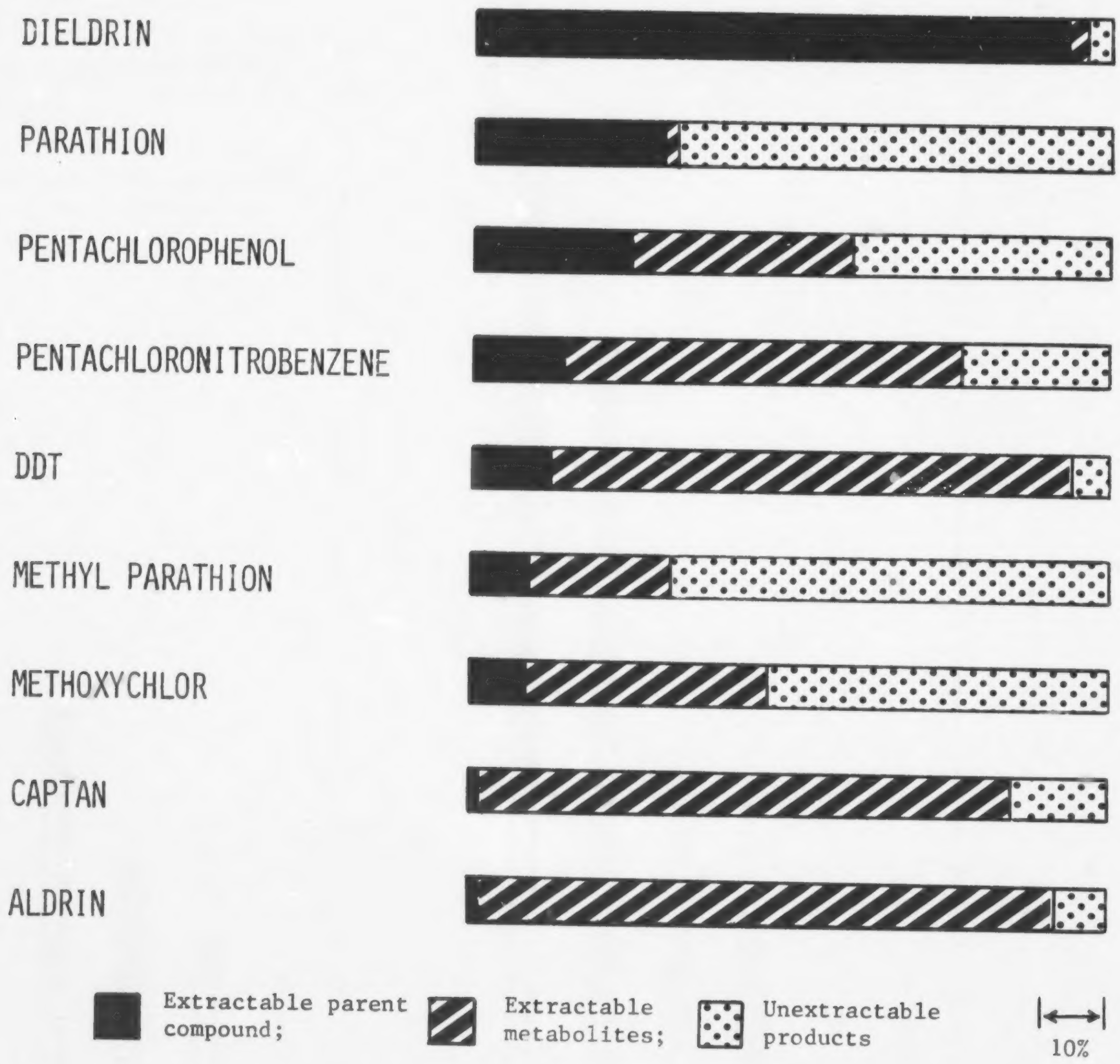


Fig. 91 .— Proportions (%) of extractable parent compound, extractable metabolites, and unextractable products detected in the total ^{14}C-pesticidal residues in the vole carcass. The carcass is the body minus its viscera and skin; it consists predominately of muscle and bone. (Degradation within other vole organs and the nature of the metabolites is described in the text.)

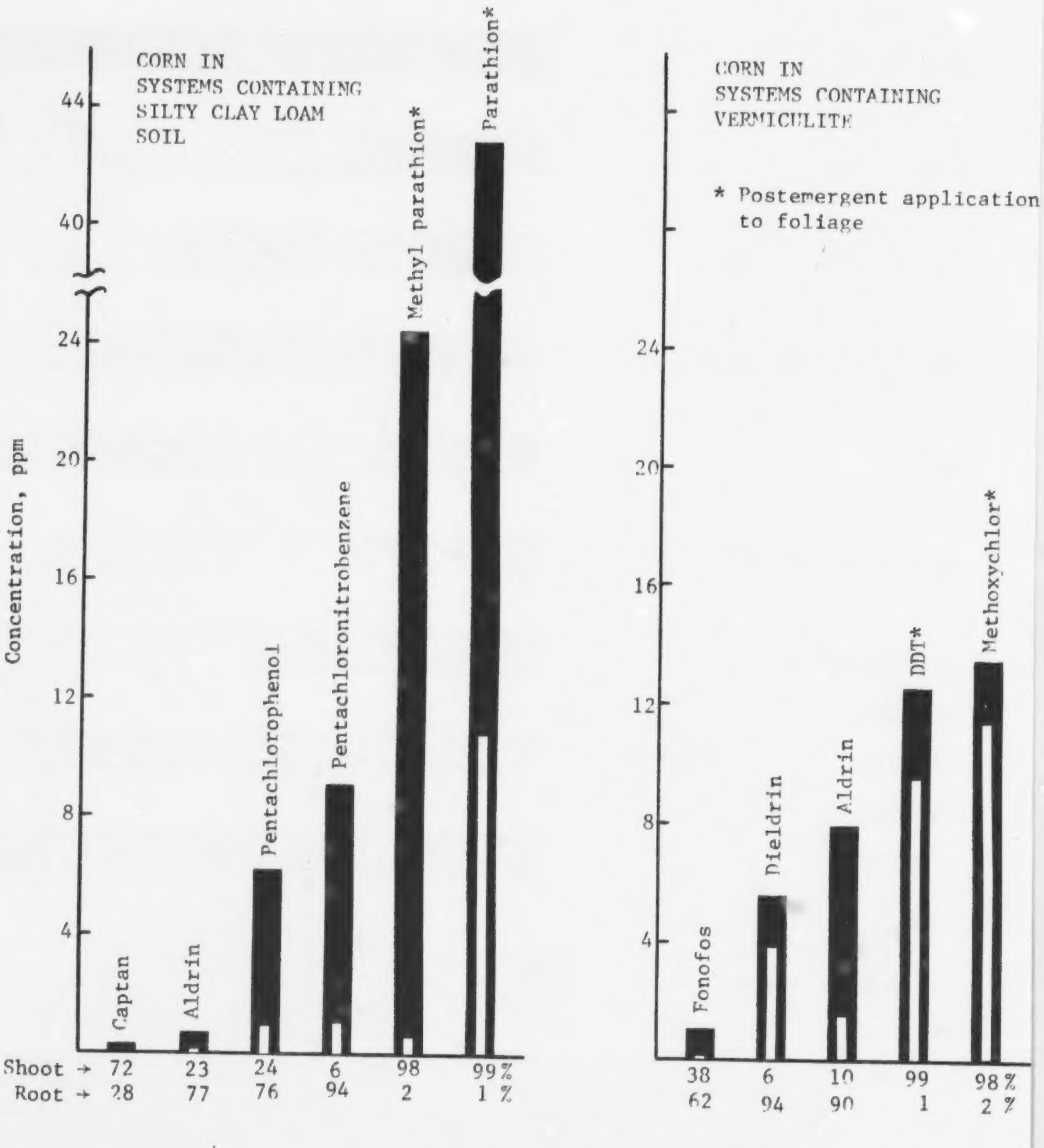
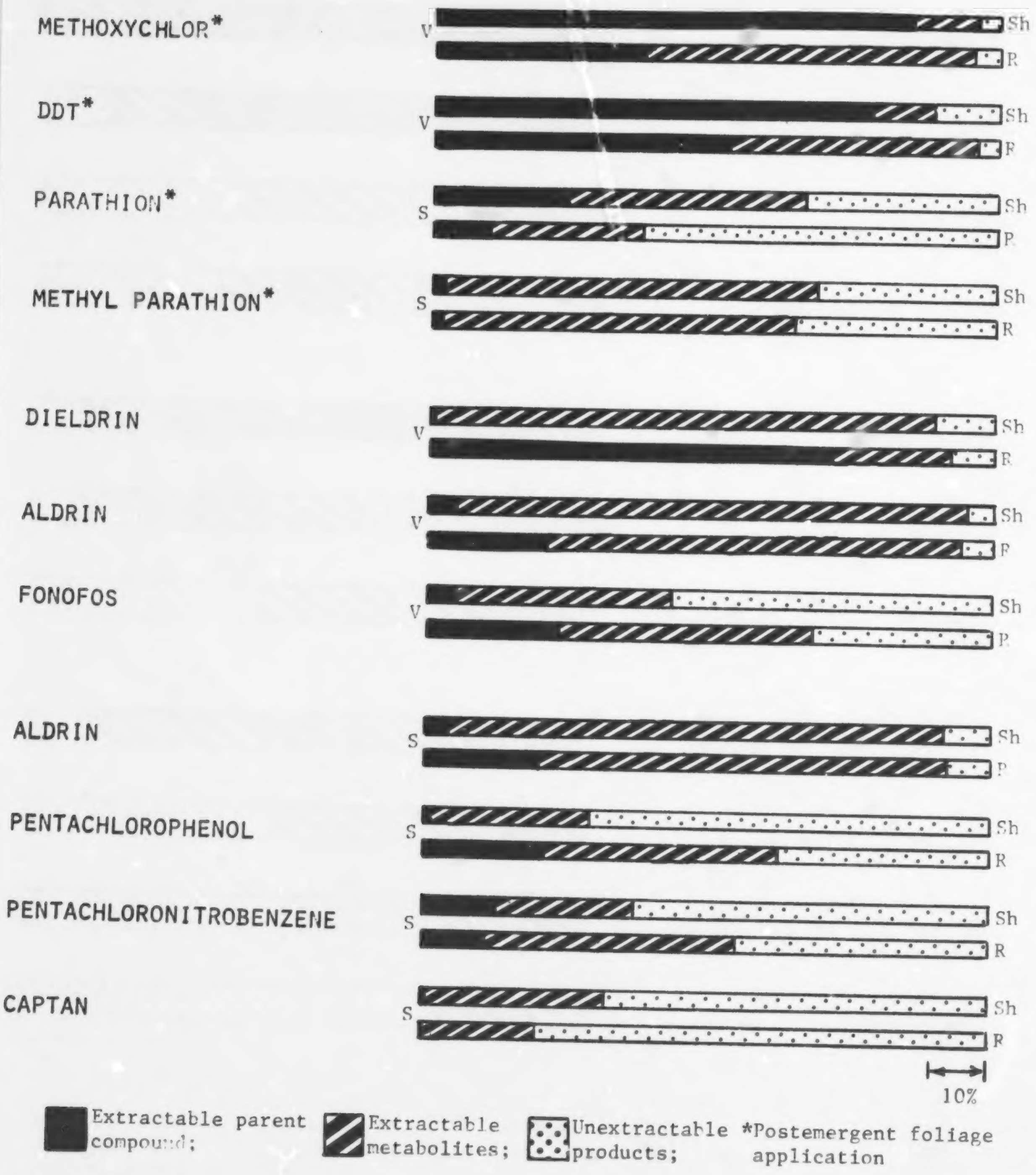
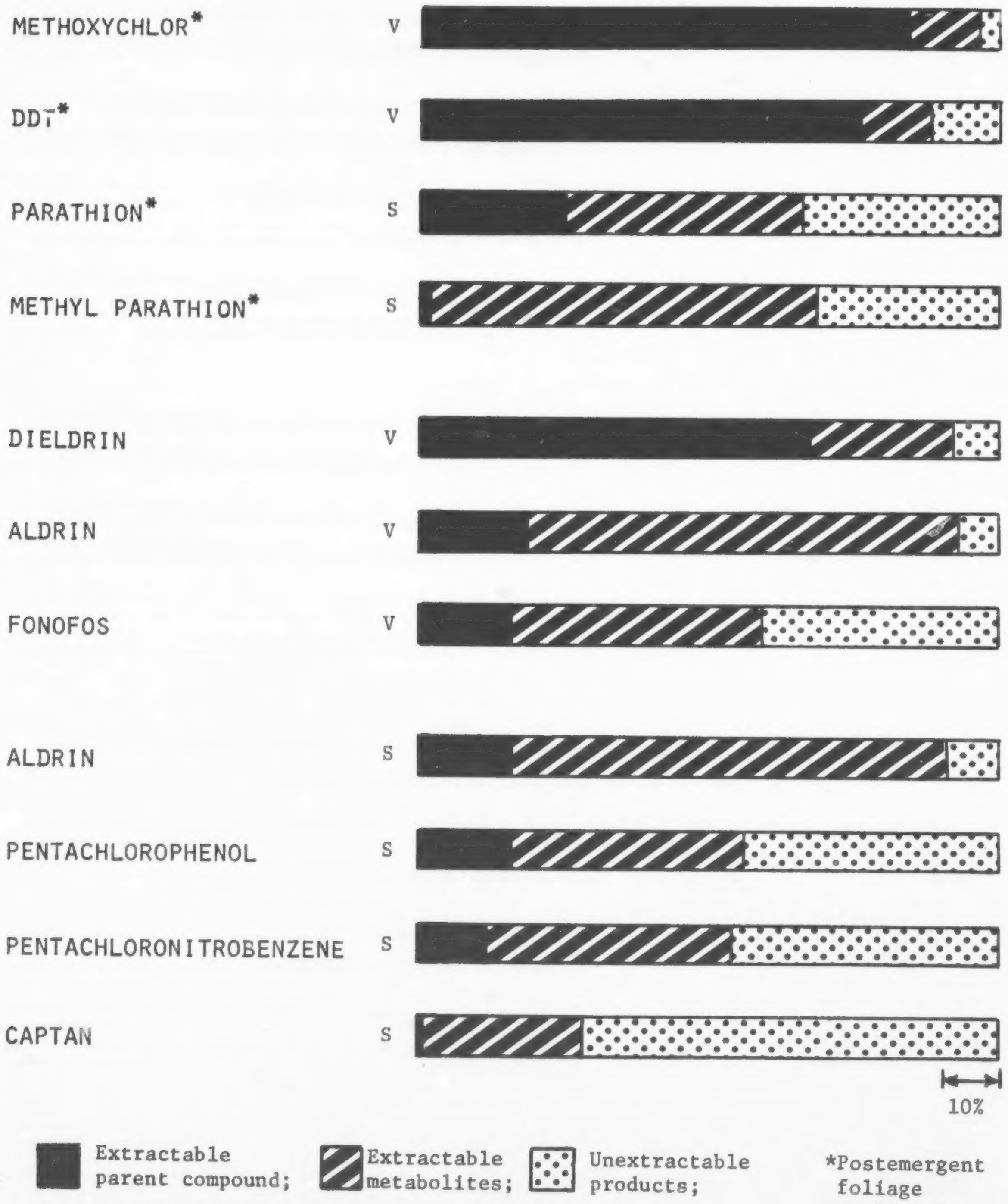


Fig.92 .—Concentrations of total ^{14}C-pesticidal residues (black bars) and parent compounds (white bars) in entire corn plants 14 days postplanting, and the proportions (%) of the residues (μg, not concentration) located in shoots and roots. Postemergent applications directly to corn foliage were made 10 days postplanting, and preemergent applications to soil were conducted at the time of planting. Each system was dosed with a single pesticide at a rate simulating one lb AI/acre.



Sh = corn shoots; R = corn roots; V = vermiculite; S = silty clay loam soil.

Fig.93 .—Proportions (%) of extractable parent compound, extractable metabolites, and unextractable products detected in the total ^{14}C-pesticidal residues from corn shoots and roots. Plants dosed by postemergent application were analyzed 4 days after dosing, and plants from systems treated with a preemergent soil application were analyzed 14 days after dosing.



*Postemergent foliage application

V = vermiculite; S = silty clay loam soil.

Fig. 94.—Proportions (%) of extractable parent compound, extractable metabolites, and unextractable products detected in the total ^{14}C-pesticidal residues from entire corn plants from terrestrial model ecosystems. Plants dosed by postemergent application were analyzed 4 days after dosing, and plants from systems treated with a preemergent soil application were analyzed 14 days after dosing.

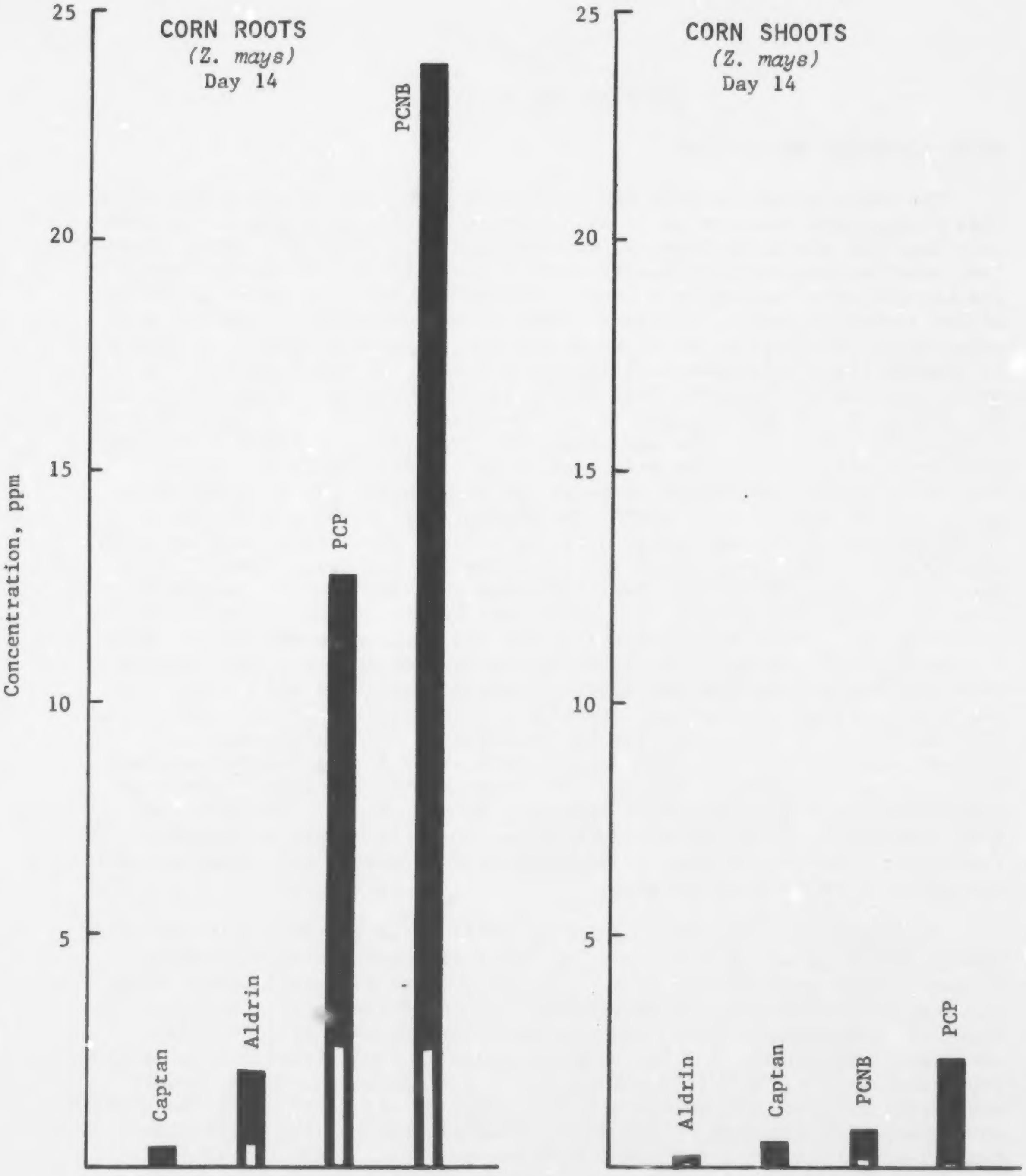


Fig. 95.—Total ^{14}C-pesticidal residues (black bars) and parent compounds (white bars) in corn roots and shoots 14 days after treating, at the time of planting, the silty clay loam soil in each system with a single pesticide at a rate simulating one lb AI/acre.

MATERIALS AND METHODS

MODEL ECOSYSTEM DESCRIPTION

The basic ecosystem unit was a 19-liter wide-mouth glass carboy 46 cm high with a base diameter of 26 cm. The metal lid, which was on the carboy only when air was being trapped, was equipped with inlet and outlet stainless steel tubing to periodically monitor pesticide vapors in air, and a plastic stopcock containing a copper wire-mesh filter was added at the base of the carboy to sample leachates. Each carboy contained either 400 g of vermiculite (Terra-Lite, W. R. Grace and Co., Cambridge, Mass.) or 3000 g of Drummer silty clay loam soil (Particle diameter 2.4-4.8 mm). Fifty corn seeds (*Zea mays*, Pioneer Hi-Bred 3334A, Pioneer Hi-Bred International, Inc., St. Joseph, Ill.) were planted in each ecosystem carboy at a depth of 1 cm. Vermiculite ecosystems were sprinkled with two liters, and soil ecosystems with one liter, of standard reference water (Freeman 1953) containing the following concentrations of salts, in ppm: $MgSO_4$, 34.6; K_2SO_4, 6.5; $MnSO_4$, 0.135; $CaCl_2$, 14.0; $NaHCO_3$ 25: NH_4NO_3, 3.0; K_2HPO_4, 0.84; $CaCO_3$, 57.5; Na_2SiO_3, 26.9; and $FeCl_3$, 0.72, at a final pH of 7.9. Each ecosystem was weighed after planting and initial watering, and again 7 and 14 days later at which times enough distilled water (ca. 600-700 ml) was added with a sprinkler to restore the initial wet weight of the system, thus simulating two rains and compensating for the evaporation of water. Both the vermiculite and the soil, when used in conjunction with the standard reference water, provided satisfactory mineral nutrition and texture for the growth of corn, cotton and soybeans. Both substrate-water combinations also sufficiently supported, for the duration of the experiments, the various invertebrate and vertebrate animals added during the terrestrial phase of the ecosystems. Furthermore, both substrates readily permitted extraction and determination of radiolabeled components. Flooding the ecosystem with 7 liters of standard reference water on Day 20 provided sufficient mineral nutrition to maintain the various aquatic organisms for the duration of the aquatic phase.

The ecosystem units were housed in a 244 x 132 x 198-cm walk-in environmental growth chamber (PGW 36, Controlled Environments, Pembina, N. Dak.) which was operated at the following parameters: Light/dark phase, 12:12 hours; continuous air circulation; day air temperature, 26°C; night air temperature, 19°C; day substrate temperature, 24-26°C; night substrate temperature 20-21°C; relative humidity, 50%; light intensity at substrate surface, 1000 foot-candles. The individual ecosystem carboys were open (covered with nylon mesh screening) to the surrounding "controlled environment" during most of the 27-day experimental period. They were semi-closed only during the hours when air was being trapped. (The semi-closed state accounted for only 2.8% of the total experimental time in those ecosystems with preemergent pesticide applications, and only 2.3% of the total time in those ecosystems with postemergent application.)

MODEL ECOSYSTEM OPERATION

For preemergent application of the pesticide, a total of 5 mg of radiolabeled compound in one ml of acetone was injected (20 µl per injection) at a depth of one cm into the substrate immediately beneath each of the 50 uniformly dispersed corn seeds at the time of planting (Day 0). For postemergent application of the pesticide, a total of 5 mg of radiolabeled compound in one ml of acetone was applied to the surface of each leaf of each corn plant (20 µl per plant) on Day 10 postplanting. The 5-mg rate of application for the 545-cm^2 growth area of the model ecosystem corresponds to about one pound of active ingredient (AI) per acre for 1.12 kg/ha), thus simulating the commonly used treatment rate in the field. For each type of application, a control ecosystem unit similarly planted with corn seeds and maintained under the same conditions as the experimental unit was teated with acetone alone.

The ecosystems were maintained for a total of 27 days, the first 20 days as the terrestrial phase and the last 7 days as the aquatic phase (Figs. 96 and 97); several pesticides were investigated using only the terrestrial phase. In the preemergent application (Day 0) ecosystems, air was sampled for 3 daylight hours on Days 0, 1, 2, 5, 11 and 19, and two corn plants were removed for analysis on Days 6, 10 and 14. In the postemergent application (Day 10) ecosystem, air was sampled for three daylight hours on Days 10, 11, 12, 15 and 19, and three corn plants were removed for analysis on Days 12 and 14. In all ecosystems, invertebrate animals usually 20 pillbugs and 10 each of the caterpillars, slugs and earthworms) were added on Day 10 (after corn plant sampling or after pesticide application). Three of each type of invertebrate animals were removed for analysis on Day 15 (after air sampling, if applicable). The vole was added to the ecosystem on Day 15, supplied with a cup of fresh water daily, and removed for analysis on Day 20. Any readily visible plant shoots and invertebrate animals remaining in the terrestrial phase were removed on Day 20 and discarded; the substrate was then mixed well and sampled for analysis. After substrate sampling on Day 20, the ecosystem was flooded with 7 liters of standard reference water, and 50 snails, about 300 mosquito larvae and about 300 daphnia were added; the latter two organisms were supplied primarily to serve as food for the fish. The surface water was mixed slightly and sampled for radioactive content daily. Three fish were added on Day 24 (4 days after flooding) and removed for analysis on Day 27; snails, any algae, and any remaining daphnia were also removed for analysis on Day 27. One liter of surface water and, if desired, one liter of leachate were collected for analysis on Day 27. The remaining surface water was decanted from the ecosystem and discarded. In earlier ecosystems, the wet sediment was left in the ecosystem container for 5 days and then mixed and sampled for analysis. In more recent ecosystems, the wet sediment was sampled on Day 28.

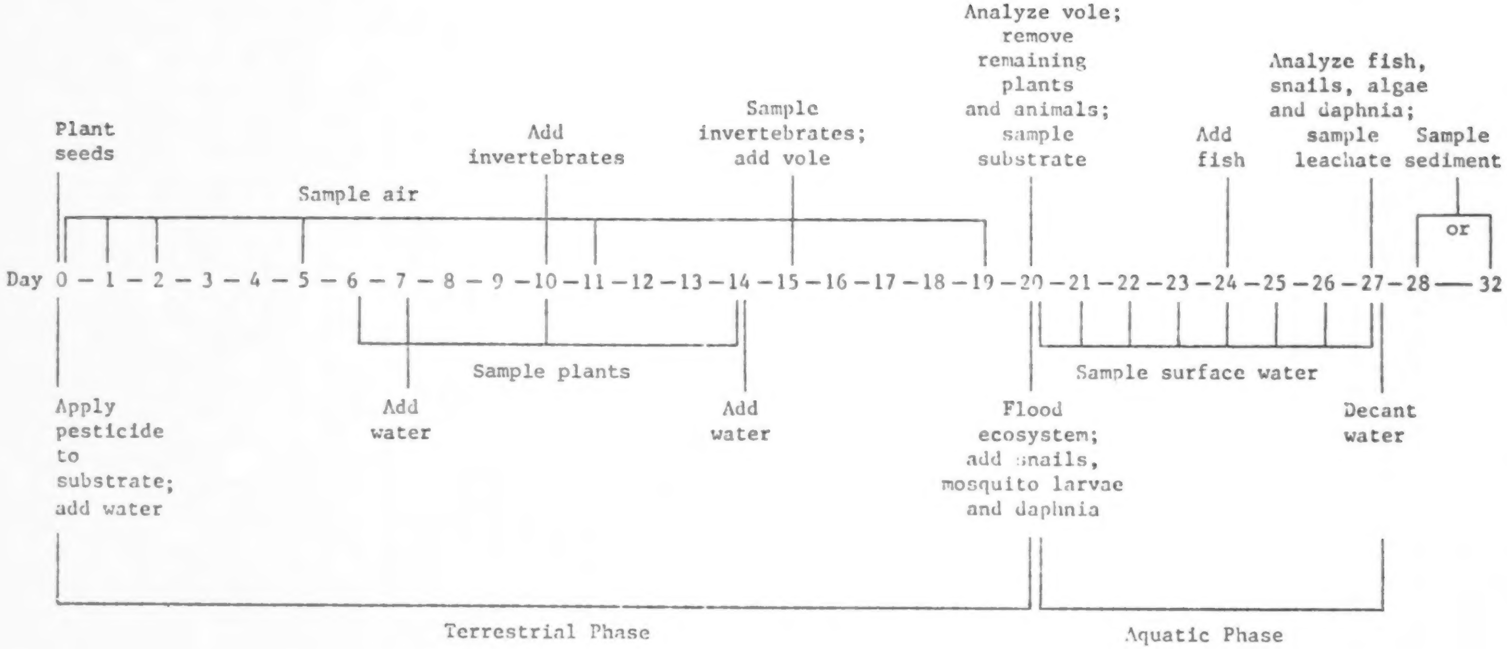

Plant seeds
Add invertebrates
Sample invertebrates; add vole
Analyze vole; remove remaining plants and animals; sample substrate
Add fish
Analyze fish, snails, algae and daphnia; sample leachate
Sample sediment
Sample air
or
Day 0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 11 – 12 – 13 – 14 – 15 – 16 – 17 – 18 – 19 – 20 – 21 – 22 – 23 – 24 – 25 – 26 – 27 – 28 — 32
Sample plants
Sample surface water
Apply pesticide to substrate; add water
Add water
Add water
Flood ecosystem; add snails, mosquito larvae and daphnia
Decant water
Terrestrial Phase
Aquatic Phase

Fig. 96. Time sequence for the model ecosystem (preemergent pesticide application)

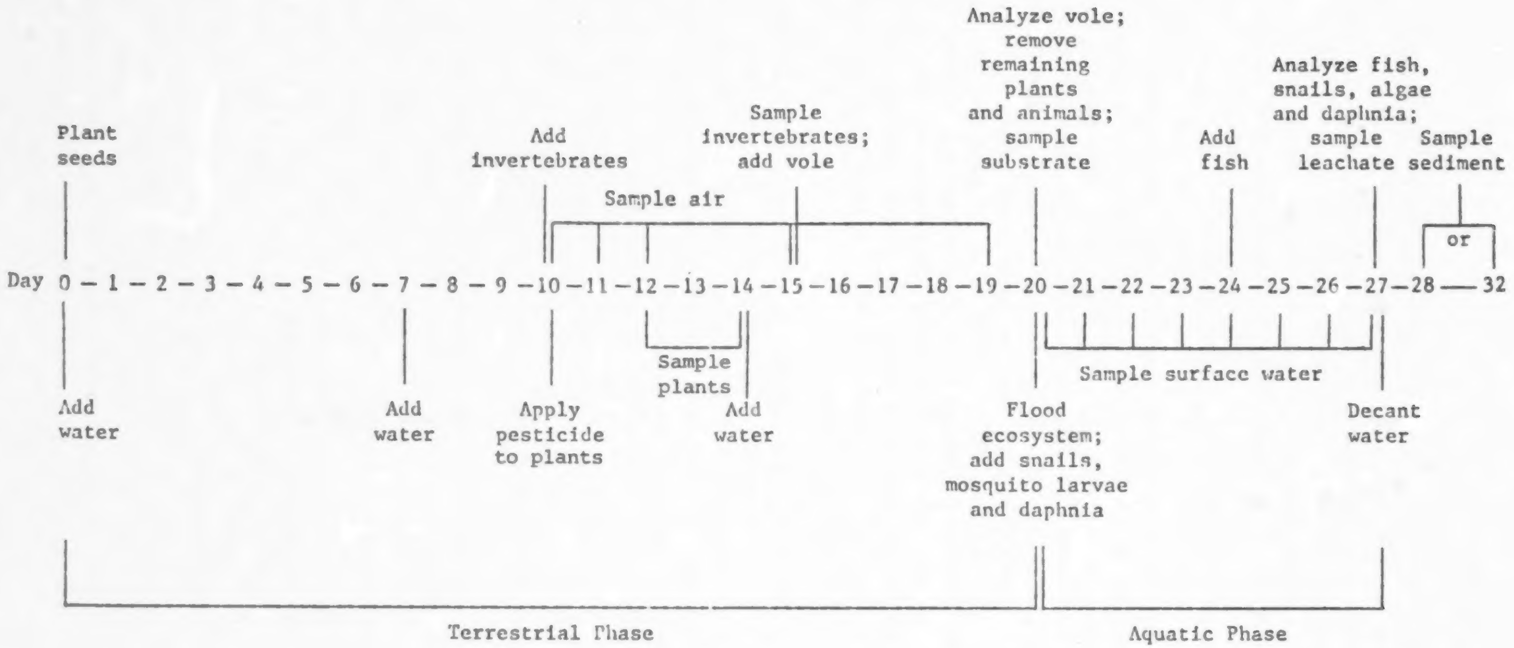

Plant seeds
Add invertebrates
Sample air
Sample invertebrates; add vole
Analyze vole; remove remaining plants and animals; sample substrate
Add fish
Analyze fish, snails, algae and daphnia; sample leachate
Sample sediment
or
Day 0 — 1 — 2 — 3 — 4 — 5 — 6 — 7 — 8 — 9 —10—11—12—13—14—15—16—17—18—19—20—21—22—23—24—25—26—27—28——32
Add water
Add water
Apply pesticide to plants
Sample plants
Add water
Sample surface water
Flood ecosystem; add snails, mosquito larvae and daphnia
Decant water
Terrestrial Phase
Aquatic Phase

Fig. 97. Time sequence for the model ecosystem (postemergent pesticide application)

MODEL ECOSYSTEM ORGANISMS

Microtus ochrogaster (Wagner), the prairie vole, was selected as the apex of the food web of the model ecosystem because voles ("field mice") are possibly the most abundant mammals in the world, and the prairie vole is particularly abundant in the central portion of the United States. Jameson (1947) states that the activities of voles, especially those of the genus *Microtus*, attracted the attention of Aristotle, who wrote: "The rate of propagation of field mice in country places, and the destruction that they cause, are all beyond telling. In many places their number is so incalculable that very little of the corn crop is left to the farmer..." The voles utilized in the ecosystems were from a laboratory colony derived from wild animals captured in Illinois. The animals were bedded on cleaned, processed and unground rice hulls (J. B. Hunt Co., Stuttgart, Ark.) and Pel-I-Cel Pelleted Corn Cob Laboratory Animal Waste Absorbent (Paxton Processing Co., Inc., Paxton, Ill.) in standard metal mouse cages, and maintained on a diet consisting of Purina Laboratory Rabbit Chow Checkers (Ralston Purina Co., St. Louis, Mo.). The vole is present in the model ecosystem during the terminal 5 days of the terrestrial phase, and at the end of this period, it not uncommon to find that many of the other organisms of the system have been consumed. In those systems containing corn, the first food preference of the vole appears to be corn, and the garden slugs appear to be the least palatable.

Estigmene acrea (Drury), the saltmarsh caterpillar, was chosen principally because of the considerable amount of information available in our laboratory regarding its ability to metabolize a variety of pesticides. It is the insect component of the model ecosystem, and thus represents the reportedly most abundant form of terrestrial life in nature. The early fifth instar larvae are active feeders on all of the crops that have been tested in the model ecosystem. The caterpillars were reared in 1-oz plastic pill cups containing a synthetic diet modified from that of Vail et al. (1967) by the addition of sorbic acid, cholesterol, wheat germ oil, linolenic acid and inositol.

Limax maximus L., a garden slug representing the phylum mollusca, was chosen because it is the most hardy of the slugs tested from the surrounding agricultural area. In abundance of species, mollusks comprise the largest invertebrate phylum aside from the arthropods. The animals were successfully maintained at 15°C in 8-inch-tall round or rectangular glass battery jars containing 3-4 cm of sand and covered with perforated aluminum foil. The sand was moistened with distilled water and sprinkled with Purina Dog Chow. Jars were cleaned and the sand and food replaced twice weekly.

Lumbricus terrestris L.,an earthworm belonging to the phylum Annelida, was used in the model ecosystem because it is representative of the abundant invertebrate fauna that lives predominately beneath the soil surface. They were successfully maintained at 15°C in a large porous wooden box containing 3-4 inches of rehydrated Buss Bed-ding (Buss Manufacturing Co., Lanarck, Ill.). The bedding was kept moist with distilled water. Each cubic foot of bedding was sufficient to support 150 small worms or 50 large worms.

Armadillidium vulgare (Latreille) is one of the pillbugs, which are the only terrestrial representatives of the crustaceans. Pillbugs possess several similarities to the Insecta including a chitinous exoskeleton and problems of maintaining water balance during the elimination of nitrogenous metabolic wastes. Evaluation of the metabolic potential and the tendency for pesticides to accumulate in pillbugs will provide valuable information for comparison to the data already available on the interactions of pesticides in insects. They were maintained at 21°C and 70% relative humidity in plastic cake boxes (perforated lids) containing 2-3 cm of a moistened mixture of soil, gravel and wood chips, and were fed sweet alyssum (*Lobularia maritima* (L.) Desv.) and small pieces of potato tuber.

The following organisms were used in the aquatic phase of the model ecosystem: *Daphnia magna* (water flea), *Culex pipiens quinquefasciatus* (mosquito larva), *Physa* sp. (snail) and *Gambusia affinis* (fish). Their successful utilization in previous model ecosystems has been described by Metcalf et al (1971, 1977).

RADIOLABELED PESTICIDES

The following ^{14}C labeled pesticides were applied to the model ecosystem:

DDT 1,1,1-trichloro-2,2-bis-(p-chlorophenyl)ethane [ring U-^{14}C] (5.48 mCi/mmol)-A[*]

methoxychlor 1,1,1-trichloro-2,2-bis-(p-methoxyphenyl)ethane [ring U-^{14}C] (4.03 mCi/mmol)-M

aldrin 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-endo-1,4-exo-dimethanonaphthalene [ring-U-^{14}C] (79 mCi/mmol)-A

dieldrin 1,2,3,4,10,10-hexachloro-exo-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene [ring-U-^{14}C] (85 mCi/mmol)-A

parathion *O,O*-diethyl *O*-p-nitrophenyl phosphorothionate [ring-2,6-^{14}C] (12.2 mCi/mmol)-A

methyl parathion O,O-diethyl O-p-nitrophenyl phosphorothionate [ring 2,6-^{14}C] (30 mCi/mmol)-A

fonofos O-ethyl S-phenyl ethylphosphonodithioate [O-ethyl-^{14}C] (2.70 mCi/mmole)-S phorate O,O-diethyl S-(2-ethylthio)-methyl phosphorodithionate [CH_2-^{14}C] (9.7 mCi/mmol)-A

hexachlorobenzene [ring U-^{14}C] (20 mCi/mmol)-N

pentachlorophenol [ring U-^{14}C] (14.05 mCi/mmol-N

pentachloronitrobenzene [ring U-^{14}C (14.5 mCi/mmol)-N

captan N-(trichloromethylthio-4-cyclohexane-1,2-dicarboximide [^{14}C-Cl_3] (23.8 mCi/mmol)-n

simazine 2-chloro-4,6-(ethylamino)-sym-triazine [ring U-^{14}C] (18.27 mCi/mmol)-n

trifluralin N,N-dipropyl-2,6-dinitro-4,trifluromethylaniline [ring U-^{14}C] (15.16 mCi/mmol)-N

2,4,5-T isoctyl ester isoctyl 2,4,5-trichlorophenoxyacetate [ring-U-^{14}C] (11.81 mCi/mmol-N

Before application to the model ecosystems, the radiolabeled chemicals were adjusted to the following specific activities:

	dpm/ g	mCi/mmol
DDT	22,163	3.54
methoxychlor	10,340	1.61
aldrin	18,851	3.10
dieldrin	21,263	3.68
parathion	31,736	4.16
methyl parathion	47,258	5.60
fonofos	24,366	2.70
phorate	72,150	8.45
hexachlorobenzene	41,518	5.33
pentachlorophenol	21,238	2.55
pentachloronitrobenzene	32,463	4.32

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[*] code A - Amersham Corp., M = Malinckrodt Chemical Works, N = New England Nuclear Corp., S = synthesized by Dr. J. R. Sanborn.

captan	22,063	2.99
simazine	44,179	4.00
trifluralin	46,751	7.05
2,4,5-T isooctyl ester	42,156	6.95

SUBSTRATE ANALYSIS

Substrates analyzed by this procedure included soil or vermiculite sampled on Day 20 of the ecosystem, and soil or vermiculite sediment sampled on Day 28 or 32, after the aquatic phase (8 or 12 days after flooding the ecosystem and 1 or 5 days after removing the surface water). The substrate was thoroughly mixed with a spatula and three random 100-g samples taken. One sample was stored in the refrigerator in an air-tight container for future use, if necessary; the second was placed in a 130°C oven for dry weight determination, the third sample was analyzed for radioactive components according to the following procedure (Fig. 98).

Repeated comparisons of Soxhlet extraction of a soil sample with 500 ml of acetone for a 24-hour period, followed by a similar extraction with 500 ml of methanol, with the homogenization-filtration procedure outlined below indicated that the latter was a more efficient procedure. The sample was homogenized with 200 ml of acetone in a 200-ml Sorvall Omni-Mixer cup at Setting 6 for 15 minutes. The cup was kept on ice during the procedure. The homogenate plus two 20-ml acetone rinses of the cup were suction-filtered through Whatman No. 2 filter paper in a Buchner funnel at full bench vacuum. The filter cake was rinsed twice, each with 20 ml of acetone, and the total acetone filtrate retained for further processing. The filter cake was then returned to the Omni-Mixer cup, 200 ml of absolute methanol added and the homogenization and filtration procedures repeated, with appropriate methanol rinses. The total methanol filtrate was retained for further processing. In earlier ecosystems, the filter cake was discarded without further analysis. In more recent ecosystems, the filter cake was dried to constant weight and aliquots were combusted in a Packard Tri-Carb Sample Oxidizer in order to determine the unextractable radioactive content.

The acetone and methanol filtrates (extracts) were transferred, with appropriate rinses of the filtration flasks, to 250-ml volumetric flasks, made up to the volume mark with the appropriate solvent, and mixed thoroughly. Triplicate 0.1-ml samples of the acetone extract and 1.0-ml samples of the methanol extract were added to scintillation vials containing Aquasol (Universal L.S.C. Cocktail, New England Nuclear, Boston, Mass.) in order to determine the radioactive content.

The acetone extract was then transferred to a 1-liter separatory funnel along with 400 ml of diethyl ether and a few grams (5-6) of sodium bisulfite. The residual acetone extract was rinsed out of the volumetric flask with portions of the ether. The separatory funnel was shaken well,

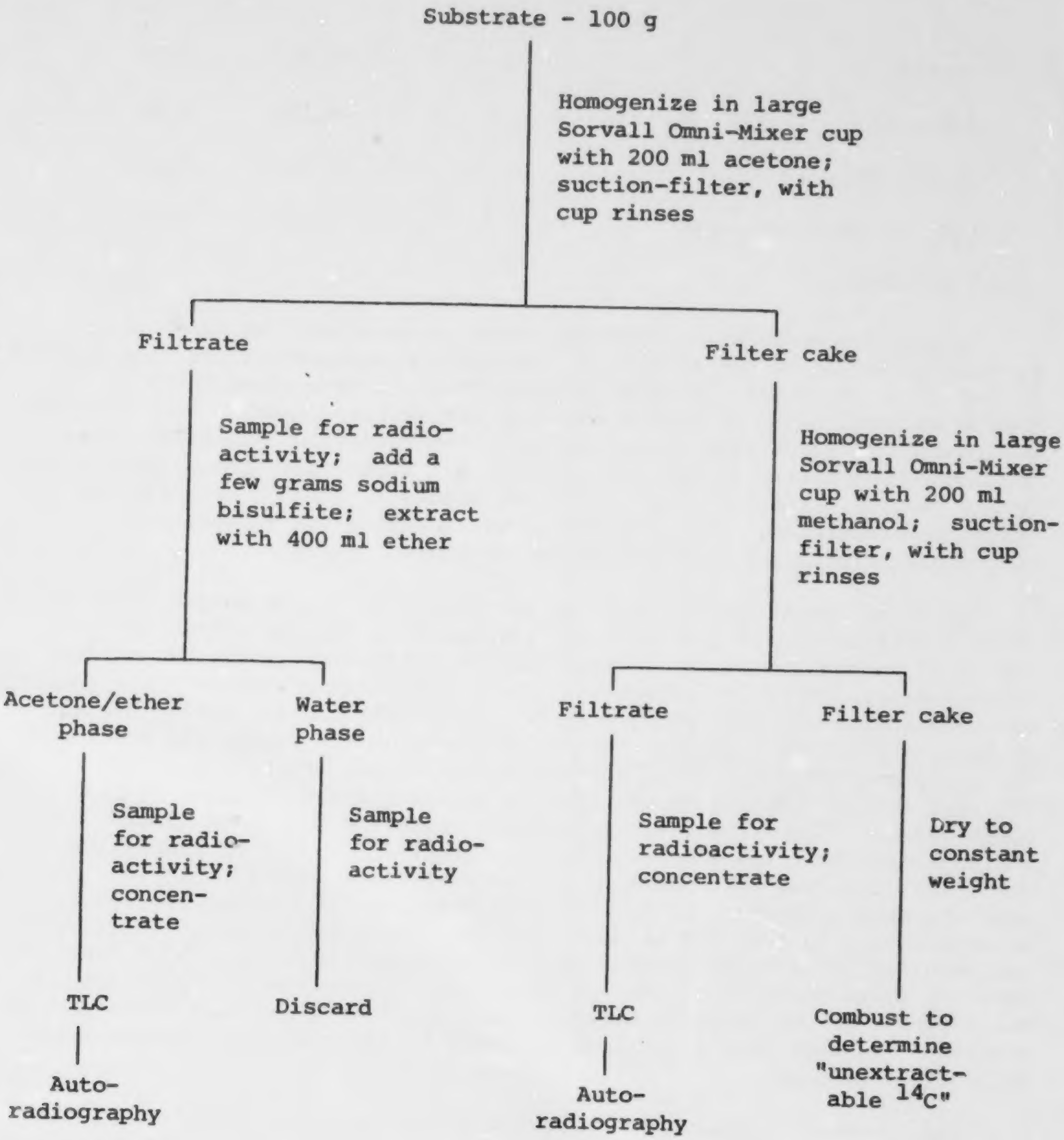

Substrate - 100 g
Homogenize in large Sorvall Omni-Mixer cup with 200 ml acetone; suction-filter, with cup rinses
Filtrate
Filter cake
Sample for radioactivity; add a few grams sodium bisulfite; extract with 400 ml ether
Homogenize in large Sorvall Omni-Mixer cup with 200 ml methanol; suction-filter, with cup rinses
Acetone/ether phase
Water phase
Filtrate
Filter cake
Sample for radioactivity; concentrate
Sample for radioactivity
Sample for radioactivity; concentrate
Dry to constant weight
TLC
Discard
TLC
Combust to determine "unextractable 14C"
Autoradiography
Autoradiography

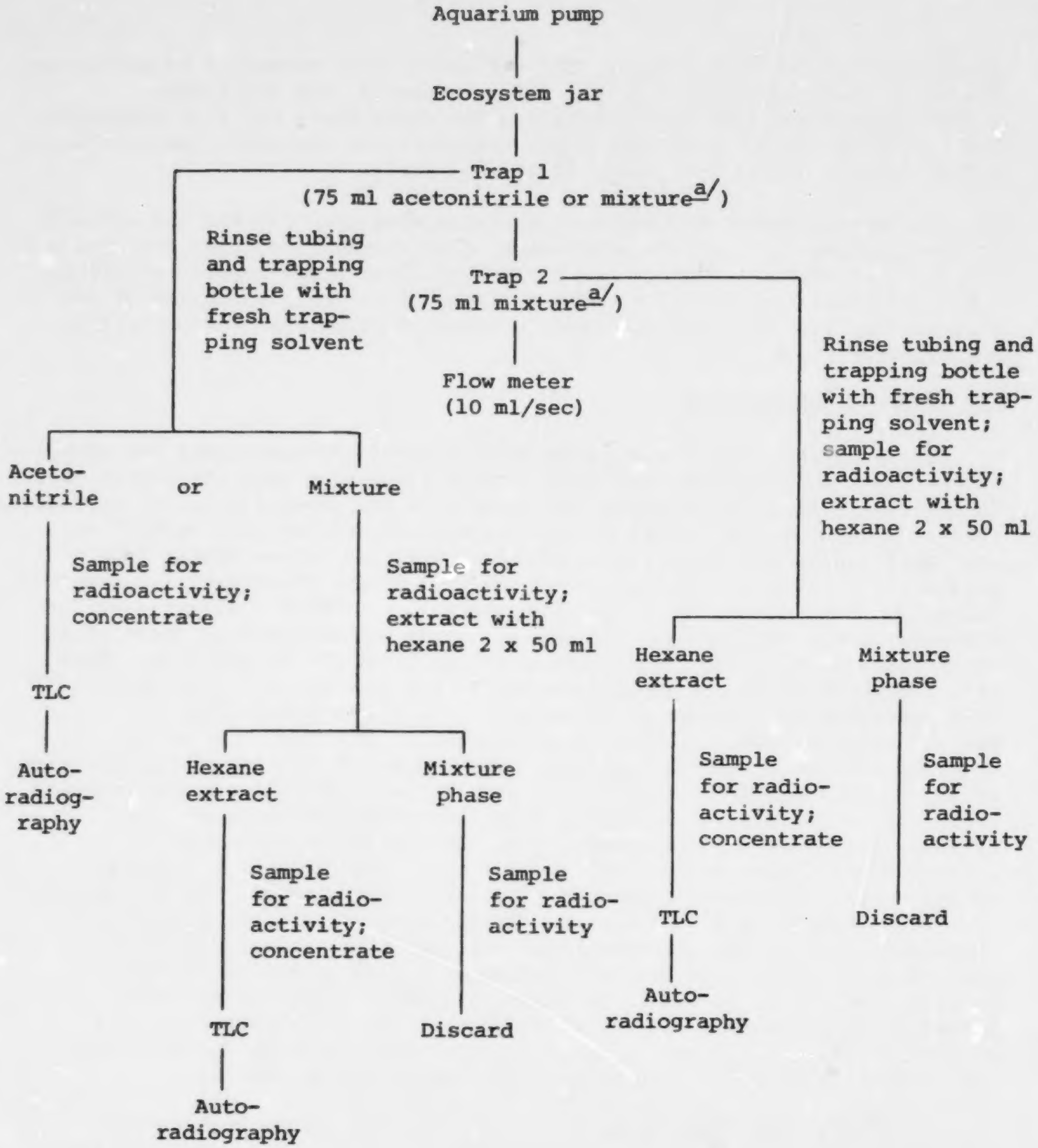
Fig. 98 . Substrate analysis procedure (vermiculite/soil/sediment) accompanied by frequent venting, and the water phase permitted to settle out. The water phase was collected, the volume measured, and triplicate 1.0-ml samples added to Aquasol vials. The water phase was then discarded. The volume of the acetone/ether phase (extract) was measured, and triplicate 0.2 or 0.5-ml samples were added to Aquasol vials.

The acetone/ether and methanol extracts were concentrated individually to small volumes in a rotary evaporator. The evaporation flask contents were then transferred, with appropriate rinses, to 15-ml screw-capped centrifuge tubes for final concentration under a stream of nitrogen. Samples of the concentrated extracts were analyzed by means of thin-layer chromatography and autoradiography.

AIR TRAPPING AND ANALYSIS

The ecosystem carboy was fitted with a metal lid containing two pieces of stainless steel tubing, the inlet tubing projecting into the carboy about 28 cm (ending about 10 cm above the surface of the substrate in the terrestrial phase), and the outlet tubing projecting into the carboy only about 4 cm. The inlet tubing was connected by means of silicone rubber tubing to a needle valve which in turn was connected to a Silent Giant aquarium pump (Aquarium Pump Supply, Inc., Prescott, Ariz.), providing a slight positive pressure within the carboy. The outlet tubing was attached by means of a short piece of silicone rubber tubing to the first of two gas traps which were connected in series and terminated with a flow meter. (The vapor trap preceding the two gas traps shown in the illustration (Fig. 1) was not routinely used in these experiments; it was used only in concomitant studies involving long-term gas trapping.) The gas traps consisted of 125-ml gas washing bottles fitted with teflon joint sleeves and standard taper tops containing glass tubing which terminated in fritted glass cylinders of extra coarse porosity. The two bottles were mounted in 4-liter Dewar flasks packed with crushed ice. The first trap (closest to the ecosystem carboy) contained 75 ml of either acetonitrile of a mixture of 2-methoxyphenol and ethanolamine (2:1 by volume), and the second trap contained 75 ml of the aforementioned mixture. The air was routinely trapped for a three-hour daylight period at a flow rate of 10 ml/sec on Days 0, 1, 2, 5, 11 and 19 of those ecosystems which had received preemergent application (Day 0) of the pesticide to the substrate, and on Days 10, 11, 12, 15 and 19 of those ecosystems in which the pesticide had been applied to the corn foliage (postemergent) on Day 10.

Following each trapping period (Fig. 99), the tubing between the ecosystem carboy and Trap 1 was rinsed with fresh Trap 1 solvent and the rinse added to Trap 1. Similarly, the tubing between Trap 1 and Trap 2 was rinsed with fresh Trap 2 solvent and the rinse added to Trap 2. The contents of each trap were mixed thoroughly, the volume measured, and triplicate 1.0-ml samples added to scintillation vials containing Aquasol in order to determine the level of radioactivity.


Aquarium pump
Ecosystem jar
Trap 1
(75 ml acetonitrile or mixture a/)
Rinse tubing and trapping bottle with fresh trapping solvent
Trap 2
(75 ml mixture a/)
Flow meter
(10 ml/sec)
Rinse tubing and trapping bottle with fresh trapping solvent; sample for radioactivity; extract with hexane 2 x 50 ml
Acetonitrile
or
Mixture
Sample for radioactivity; concentrate
Sample for radioactivity; extract with hexane 2 x 50 ml
Hexane extract
Mixture phase
TLC
Autoradiography
Hexane extract
Mixture phase
Sample for radioactivity; concentrate
Sample for radioactivity
Sample for radioactivity; concentrate
Sample for radioactivity
TLC
Discard
TLC
Discard
Autoradiography
Autoradiography

a/ 2-methoxyethanol : ethanolamine, 2:1 by volume

Fig. 99 . Air trapping and analysis procedure

Where acetonitrile was the trapping solvent, the acetonitrile after trapping was evaporated to a small volume in a rotary evaporator. The evaporation flask contents were then transferred, with ether rinses, to a 15-ml screw-capped centrifuge tube for final concentration under a stream of nitrogen. Samples of the concentrate were analyzed by means of thin-layer chromatography and autoradiography.

Where the mixture was the trapping solvent, the mixture after trapping was transferred to a 250-ml separatory funnel and extracted two times, each with 50 ml of hexane. The hexane extracts were combined, the volume measured, and triplicate 1.0-ml samples added to vials containing dioxane-based scintillation fluid. The extract was concentrated as usual and analyzed by means of thin-layer chromatography-autoradiography. The mixture phase was collected, the volume measured, and triplicate 1.0-ml samples added to Aquasol vials. The remainder of the mixture phase was discarded.

WATER ANALYSIS

Daily, after gentle stirring of the surface water, triplicate 1.0-ml samples were withdrawn and added to scintillation vials containing Aquasol in order to determine radioactive content. On Day 27 of the ecosystem (7 days after flooding), one liter of surface water was withdrawn and analyzed by the procedure outlined below (Fig. 100). For selected ecosystems, one liter of leachate was drained from the bottom of the ecosystem on Day 27 and also analyzed by the following procedure.

The water was transferred to a 2-liter separatory funnel and extracted three times, each with 250 ml of diethyl ether (or chloroform if the pesticide was insoluble in the ether). The ether extracts were combined, the volume measured, and triplicate 1.0-ml samples added to scintillation vials containing dioxane-based scintillation fluid. The ether extract was retained for further processing.

The water phase was collected, the volume measured, and triplicate 1.0-ml samples added to Aquasol vials. The water was then transferred to a 2-liter standard taper Erlenmeyer flask, followed by 1 ml of concentrated hydrochloric acid (= final concentration of 0.012 N, pH 0.2) and a magnetic stirring bar. The flask was fitted with a Snyder column and heated at 556-56°C, with stirring, for 18-24 hours in order to hydrolyze conjugated compounds present in the water. After the hydrolysis period, the water was cooled to room temperature, the volume measured, and triplicate 1.0-ml samples added to Aquasol vials.

The hydrolyzed water was then transferred to a 2-liter separatory funnel and extracted with ether (or chloroform) as before. The ether extracts were combined, the volume measured, and triplicate 1.0-ml samples added to vials containing dioxane-based fluid. The ether extract was retained for further processing. The water phase was collected, the volume measured, and triplicate 1.0-ml samples added to Aquasol vials. The remainder of the water phase was discarded.

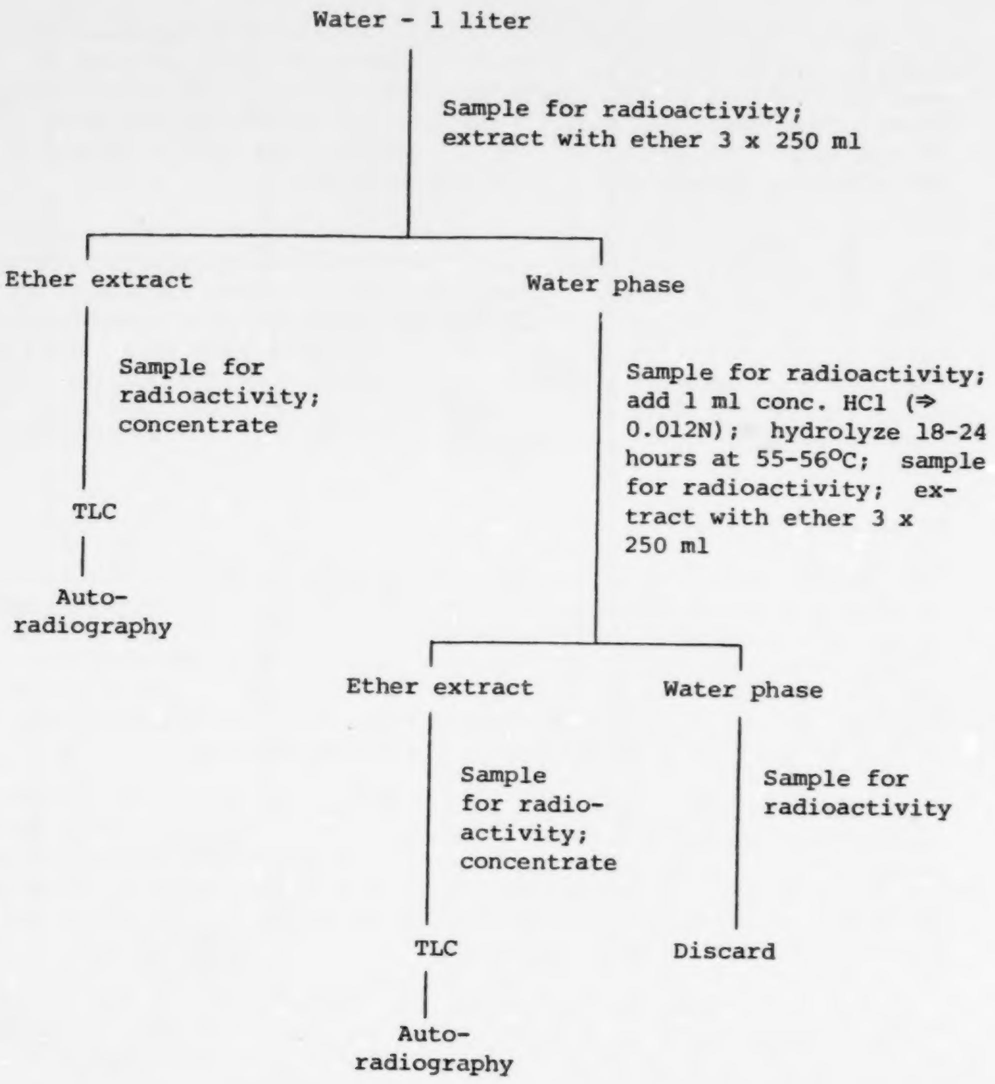

Water - 1 liter
Sample for radioactivity; extract with ether 3 x 250 ml
Ether extract
Water phase
Sample for radioactivity; concentrate
TLC
Autoradiography
Sample for radioactivity; add 1 ml conc. HCl (⇒ 0.012N); hydrolyze 18-24 hours at 55-56°C; sample for radioactivity; extract with ether 3 x 250 ml
Ether extract
Water phase
Sample for radioactivity; concentrate
TLC
Autoradiography
Sample for radioactivity
Discard

Fig.100. Water analysis procedure (surface water/leachate)

The two ether extracts, before and after hydrolysis, were concentrated individually to small volumes in a rotary evaporator. The evaporation flask contents were then transferred, with appropriate rinses, to 15-ml screw-capped centrifuge tubes for final concentration under a stream of nitrogen. Samples of the concentrated extracts were analyzed by means of thin-layer chromatography and autoradiography.

CORN ANALYSIS

Two corn plants were removed from the substrate on Days 6, 10 and 14 of those ecosystems which had received preemergent application (Day 0) of the pesticide to the substrate, and three plants were removed on Days 12 and 14 of those ecosystems in which the pesticide had been applied to the corn foliage (postemergent) on Day 10. Care was taken to retain the maximum portion of the root system of each plant. Roots were rinsed free of adhering substrate and blotted dry. The plant was severed at the crown, and the root and shoot portions weighed. Root and shoot portions were processed individually (Fig. 101). Any readily visible plant shoots still present at the end of the terrestrial phase (Day 20) were removed and discarded.

The sample was cut into small pieces and homogenized with 10 ml of acetone in a 50-ml Sorvall Omni-Mixer cup at Setting 6 for 5 minutes. The homogenate was transferred to a 15-ml screw-capped graduated centrifuge tube, along with a 5-ml rinse of the cup, and centrifuged in a clinical centrifuge at medium speed for 5 minutes. The supernatant was transferred to a 25-ml graduated cylinder. The pellet was resuspended in 5 ml of acetone, mixed well, and again centrifuged. This supernatant was combined with the first supernatant and mixed well, the volume was measured, and triplicate 0.1 or 0.2-ml samples were added to scintillation vials containing Aquasol in order to determine radioactive content. The supernatant (extract) was retained for further processing.

The centrifuge tube containing the pellet (residue) was rotated so that the contents coated the lower walls of the tube. The residue was permitted to air-dry, and was then pulverized with a pointed spatula or a glass rod. A small amount (about 0.5 ml) of distilled water was added to saturate the residue, followed by 3 ml of Protosol (Tissue and Gel Solubilizer, New England Nuclear, Boston, Mass.). The tube contents were thoroughly mixed by vortexing and/or with a glass rod. The tube was tightly capped and incubated in a 50°C water bath for 48 hours with shaking; at least once during the incubation period the tube contents were again thoroughly mixed. The dissolved residue was then diluted to 10 ml with Aquasol and mixed well. Triplicate 0.1 or 0.2-ml or other appropriate-size samples were added to Aquasol vials; when a 0.5 or 1.0-m sample was used, 0.05 or 0.1 ml of glacial acetic acid was added in order to neutralize the vial contents and minimize chemiluminescence. The remainder of the diluted residue was discarded.

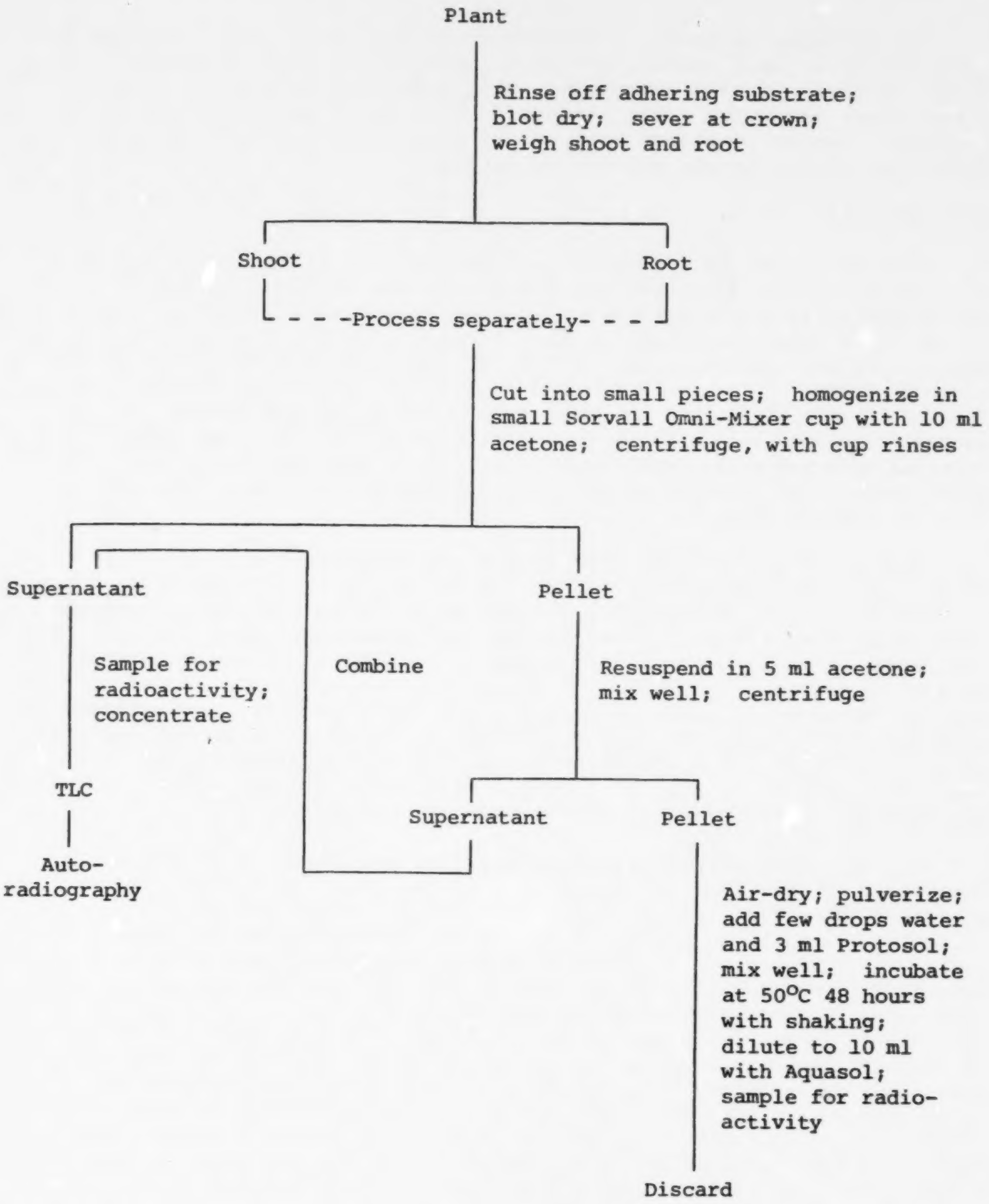

Plant
Rinse off adhering substrate; blot dry; sever at crown; weigh shoot and root
Shoot
Root
-Process separately-
Cut into small pieces; homogenize in small Sorvall Omni-Mixer cup with 10 ml acetone; centrifuge, with cup rinses
Supernatant
Pellet
Sample for radioactivity; concentrate
Combine
Resuspend in 5 ml acetone; mix well; centrifuge
TLC
Supernatant
Pellet
Auto-radiography
Air-dry; pulverize; add few drops water and 3 ml Protosol; mix well; incubate at 50°C 48 hours with shaking; dilute to 10 ml with Aquasol; sample for radio-activity
Discard

Fig. 101. Plant analysis procedure

The acetone extract was concentrated to a small volume in a rotary evaporator. The evaporation flask contents were then transferred, with acetone and ether rinses, to a 15-ml screw-capped centrifuge tube for final concentration under a stream of nitrogen. Samples of the concentrated extract were analyzed by means of thin-layer chromatography and autoradiography.

INVERTEBRATE ANIMALS ANALYSIS

Organisms analyzed by this procedure (Fig. 102) included pillbugs, slugs, caterpillars and earthworms. These animals had been added to the ecosystem on Day 10 (during the terrestrial phase). Representative live specimens (usually three of each type of animal) were removed 5 days later for analysis; any invertebrate animals still present in the ecosystem on Day 20 were removed and discarded. Slugs, caterpillars and earthworms were processed individually, and pillbugs either individually or in batches of three. If necessary, earthworms and slugs were rinsed free of adhering substrate and blotted dry. The animals were weighed and then frozen.

The organism was minced into small pieces and homogenized, a few pieces added at a time, in a glass tissue grinder with a 8 ml (small organism - pillbug, caterpillar) or 10 ml (large organism - slug, earthworm) of acetone. The homogenate was transferred to a 15-ml screw-capped graduated centrifuge tube, along with a 3 or 5-ml rinse of the grinder, and centrifuged in a clinical centrifuge at medium speed for 10 minutes. The supernatant was transferred to either another graduated centrifuge tube (small organism) or a 25-ml graduated cylinder (large organism). The pellet was resuspended in 4 or 5 ml of acetone, mixed well, and again centrifuged. This supernatant was combined with the first supernatant and mixed well. In the case of the large organisms, the pellet wash was repeated if the supernatant was still highly colored (yellow). The supernatant volume was measured, and triplicate 0.1 or 0.2-ml samples were added to scintillation vials containing Aquasol in order to determine radioactive content. The supernatant (extract) was concentrated and analyzed by the same procedure used for corn extracts.

The centrifuge tube containing the pellet (residue)was rotated so that the contents coated the lower walls of the tube. The residue was permitted to air-dry, and was then pulverized with a pointed spatula or a glass rod. Each small organism residue was processed en toto. For the large organisms, however, the total weight of the pulverized residue was recorded; triplicate 100-mg samples were weighed out and processed individually. The residues were processed by the same procedure used for corn residues except that only 2 ml of Protosol were added to each tube.

VOLE ANALYSIS

The prairie vole, which had been added to the ecosystem on Day 15, was removed from the ecosystemon Day 20, the end of the terrestrial phase, and sacrificed by ether inhalation. The animal was weighed, washed under running tap water, rinsed in a water-acetone mixture, and air-dried (Fig. 103.) After removal of the skin, the following internal organs and

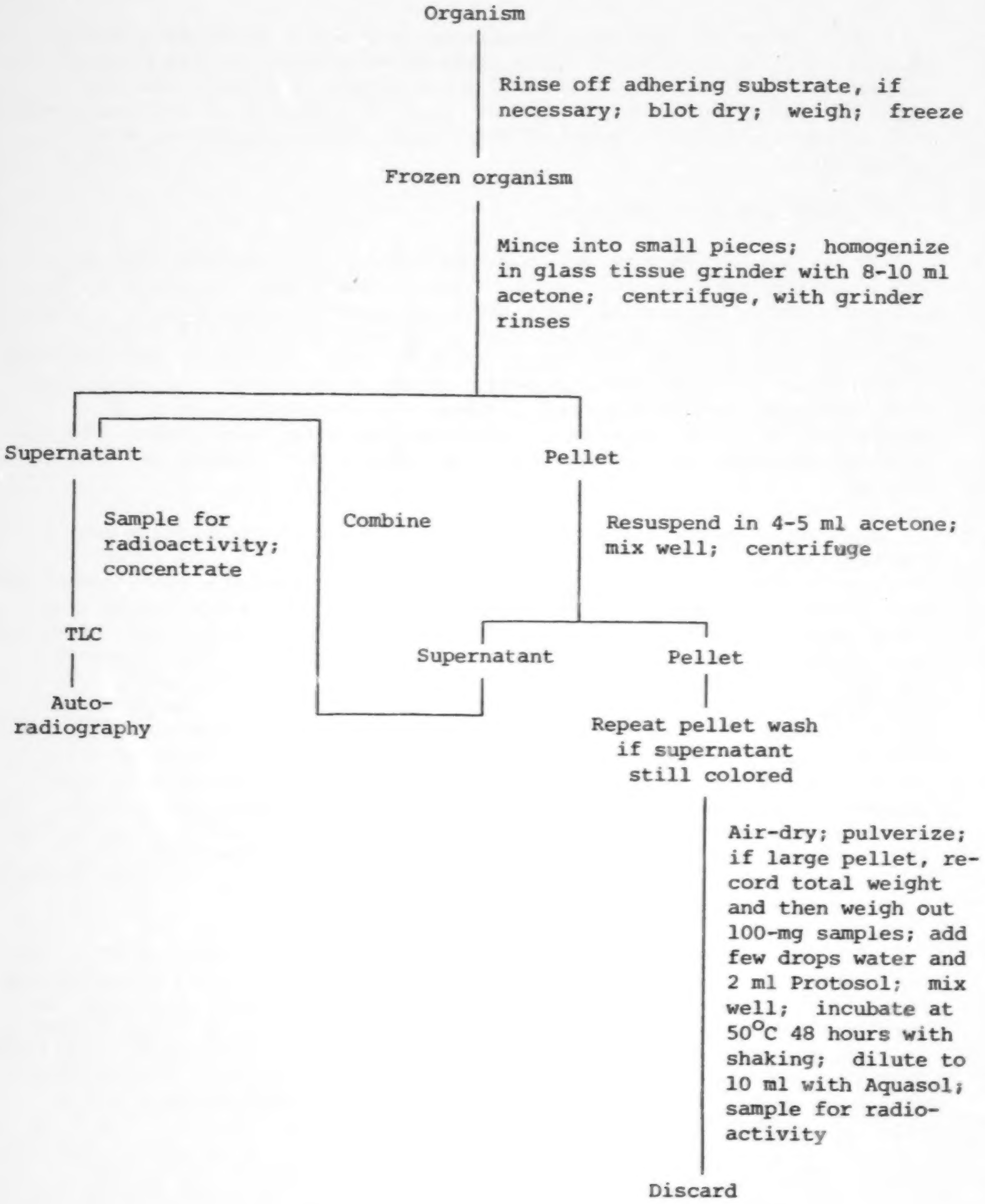

Organism
Rinse off adhering substrate, if necessary; blot dry; weigh; freeze
Frozen organism
Mince into small pieces; homogenize in glass tissue grinder with 8-10 ml acetone; centrifuge, with grinder rinses
Supernatant
Sample for radioactivity; concentrate
TLC
Auto-radiography
Combine
Pellet
Resuspend in 4-5 ml acetone; mix well; centrifuge
Supernatant
Pellet
Repeat pellet wash if supernatant still colored
Air-dry; pulverize; if large pellet, record total weight and then weigh out 100-mg samples; add few drops water and 2 ml Protosol; mix well; incubate at 50°C 48 hours with shaking; dilute to 10 ml with Aquasol; sample for radioactivity
Discard

Fig. 102. Invertebrate animal analysis procedure (pillbugs/slugs/caterpillars/pupae/earthworms)

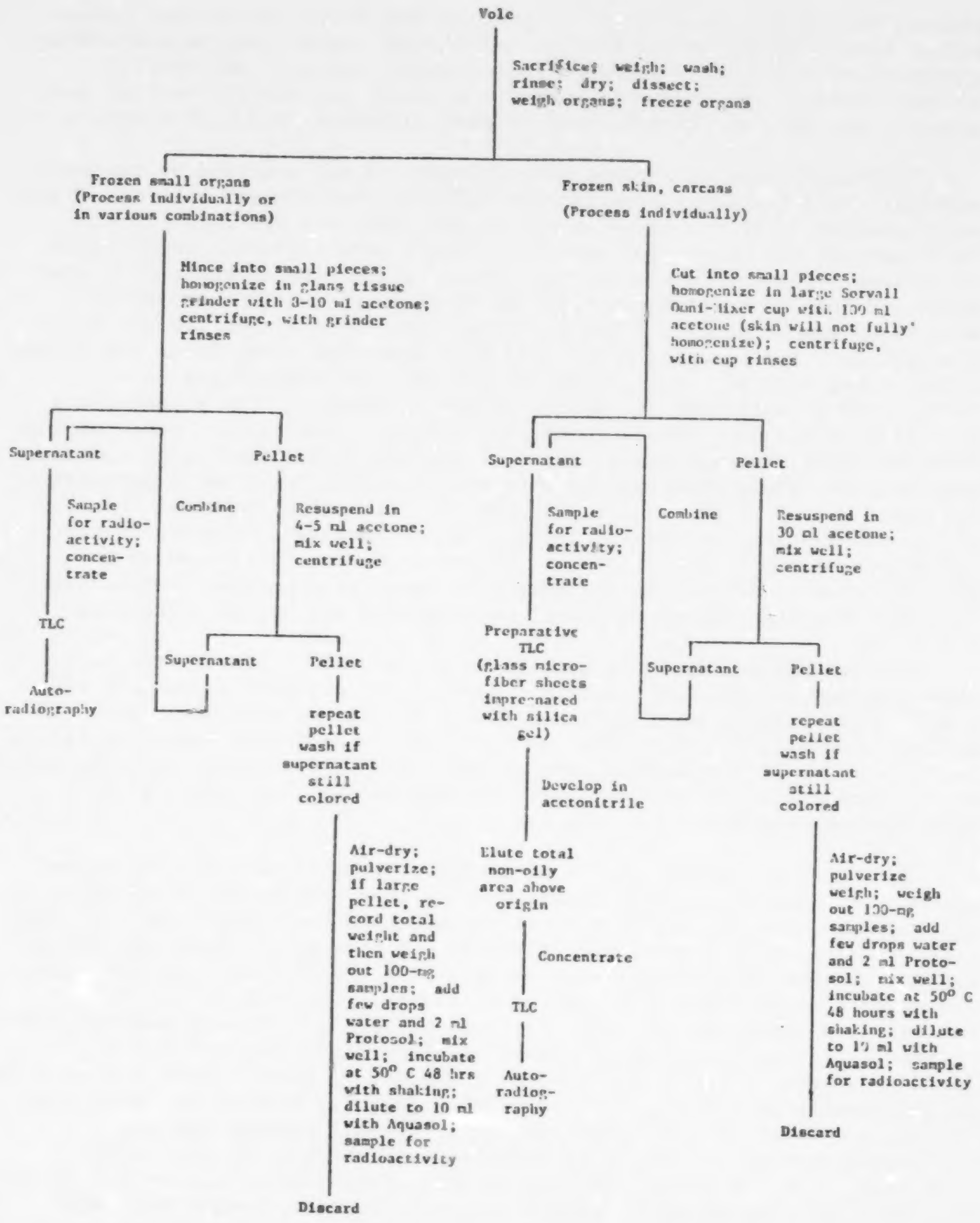

Vole
Sacrifice; weigh; wash; rinse; dry; dissect; weigh organs; freeze organs
Frozen small organs (Process individually or in various combinations)
Frozen skin, carcass (Process individually)
Mince into small pieces; homogenize in glass tissue grinder with 8-10 ml acetone; centrifuge, with grinder rinses
Cut into small pieces; homogenize in large Sorvall Omni-Mixer cup with 100 ml acetone (skin will not fully homogenize); centrifuge, with cup rinses
Supernatant
Combine
Pellet
Sample for radioactivity; concentrate
Resuspend in 4-5 ml acetone; mix well; centrifuge
TLC
Auto-radiography
Supernatant
Pellet
repeat pellet wash if supernatant still colored
Air-dry; pulverize; if large pellet, record total weight and then weigh out 100-mg samples; add few drops water and 2 ml Protosol; mix well; incubate at 50° C 48 hrs with shaking; dilute to 10 ml with Aquasol; sample for radioactivity
Discard
Supernatant
Combine
Pellet
Sample for radioactivity; concentrate
Resuspend in 30 ml acetone; mix well; centrifuge
Preparative TLC (glass microfiber sheets impregnated with silica gel)
Develop in acetonitrile
Elute total non-oily area above origin
Concentrate
TLC
Auto-radiography
Supernatant
Pellet
repeat pellet wash if supernatant still colored
Air-dry; pulverize weigh; weigh out 100-mg samples; add few drops water and 2 ml Protosol; mix well; incubate at 50° C 48 hours with shaking; dilute to 10 ml with Aquasol; sample for radioactivity
Discard

Fig. 103 Vole analysis procedure

tissues were dissected from the animal, weighed individually, and frozen: brain; heart; lungs; liver; kidneys and adrenal glands; uterus and ovaries; gastrointestinal tract and contents, abdominal, pectoral and uterine adipose tissues, when present; mammary, parotid, and ventral central neck glands. The skin and carcass were weighed individually and then frozen.

Individual internal organs were homogenized and analyzed by the same procedure used for small invertebrate animals; when several internal organs were combined to be processed en masse, the procedure for large invertebrate animals was used. The skin and carcass were processed individually as follows. The sample was cut into small pieces with scissors or a razor blade and then homogenized with 100 ml of acetone in a 200-ml Sorvall Omni-Mixer cup at Setting 6 for 15 minutes (the skin pieces did not fully homogenize). The homogenate was transferred to five 30-ml Corex centrifuge tubes, along with two 10-ml rinses of the cup, and centrifuged in a Sorvall RC2-B centrifuge at 12,000 rpm for 10 minutes. The supernatants were transferred to a 250-ml graduated cylinder. The pellets were combined into two tubes, resuspended in 15 ml of acetone each, mixed well, and again centrifuged. These supernatants were combined with the first supernatants and mixed well. In the case of the carcass, the pellet wash was repeated if the supernatants were still highly colored (yellow). The supernatant volume was measured, and triplicate 0.1 or 2-ml samples were added to scintillation vials containing Aquasol in order to determine radioactive content. The supernatant (extract) was retained for further processing.

The two pellets for each sample were permitted to air-dry and were then combined and weighed. Combined carcass pellets were pulverized with a mortar and pestle, and triplicate 100-mg samples weighed out. Skin pellets consisted of loose hair and small pieces of intact skin; triplicate representative 100-mg samples were weighed out. The residues were processed by the same procedure used for corn residues except that only 2 ml of Protosol were added to each tube.

Each acetone extract was concentrated to a small volume in a rotary evaporator. The evaporation flask contents were then transferred, with acetone and other rinses, to a 15-ml screw-capped centrifuge tube for final concentration under a stream of nitrogen. At this stage, both the carcass extract and the skin extract were largely oil; the oil layer in each case contained essentially all of the radioactivity. The bulk of the radioactivity was recovered from the oil layer by means of preparative thin-layer chromatography on silica gel-impregnated glass fiber sheets (ITLC-SG, 20x20 cm sheets, Gelman Instrument Co., Ann Arbor, Mich.) using acetonitrile as the developing solvent. The total non-oily area between the origin and the solvent front of each sheet was cut into small squares and the radioactive components eluted by leaching with about 40 ml of acetone containing about 1% water, followed by an acetone rinse. Elutes and rinses from replicate sheets were combined and centrifuged to remove suspended silica gel particles. The resulting carcass and skin supernatants (extracts) were concentrated and analyzed by the same prodedure used for corn extracts.

AQUATIC ORGANISM ANALYSIS

Organisms analyzed by this procedure (Fig. 104) included fish, snails, daphnia and algae. They were removed from the ecosystem on Day 27, the end of the aquatic phase, the fish after a 3-day exposure, and the other organisms after a 7-day exposure. The three fish were processed individually, the snails in batches of 15, the daphnia en masse as a single sample, and the algae as a single sample. Fish and snails were blotted dry and then weighed; daphnia and algae were suction-filtered to damp dryness and then weighed. If organisms could not be processed immediately, they were frozen.

The organism was minced into small pieces (necessary only for fish) and homogenized in a glass tissue grinder with 8 ml of acetone. The homogenate was transferred to a 15-ml screw-capped graduated centrifuge tube, along with a 5-ml rinse of the grinder, and centrifuged in a clinical centrifuge at medium speed for 10 minutes. The supernatant was transferred to a 25-ml graduated cylinder. The pellet was resuspended in 5 ml of acetone, mixed well, and again centrifuged. This supernatant was combined with the first supernatant and mixed well; the volume was measured, and triplicate 0.1 or 0.2-ml samples were added to scintillation vials containing Aquasol in order to determine radioactive content. The supernatant (extract) was concentrated and analyzed by the same procedure used for corn extracts.

The pellets (residues) were processed by the same procedure used for corn residues except that only 2 ml of Protosol were added to each tube.

RADIOACTIVITY MEASUREMENTS

The radioactive content of samples was measured by liquid scintillation counting in a Packard Model 3320 Tri-Carb Liquid Scintillation Spectrometer. Aquasol was used for counting samples dissolved in aqueous or polar organic solvents. Samples dissolved in nonpolar organic solvents were counted in a dioxane-based cocktail of the following composition: naphthalene, 120 g; *p*-*bis*-[2-(5-phenyl-oxazolyl)] benzene (POPOP), 0.05 g; 2,5-diphenyloxazole (PPO), 7.0 g; and 1,4-dioxane, 1 liter. All samples were counted for 10-minute periods. All counts were corrected for background and counting efficiency.

THIN-LAYER CHROMATOGRAPHY AND AUTORADIOGRAPHY

Thin-layer chromatographic analyses were carried out using 20x20-cm and occasionally 5x20-cm glass plates coated with 0.25 or 0.5-mm-thick layers of Silica Gel GF-254 (E. Merck, Darmstadt, Germany). The plates were activated in a 100° oven for one hour and stored in a desiccator box until used.

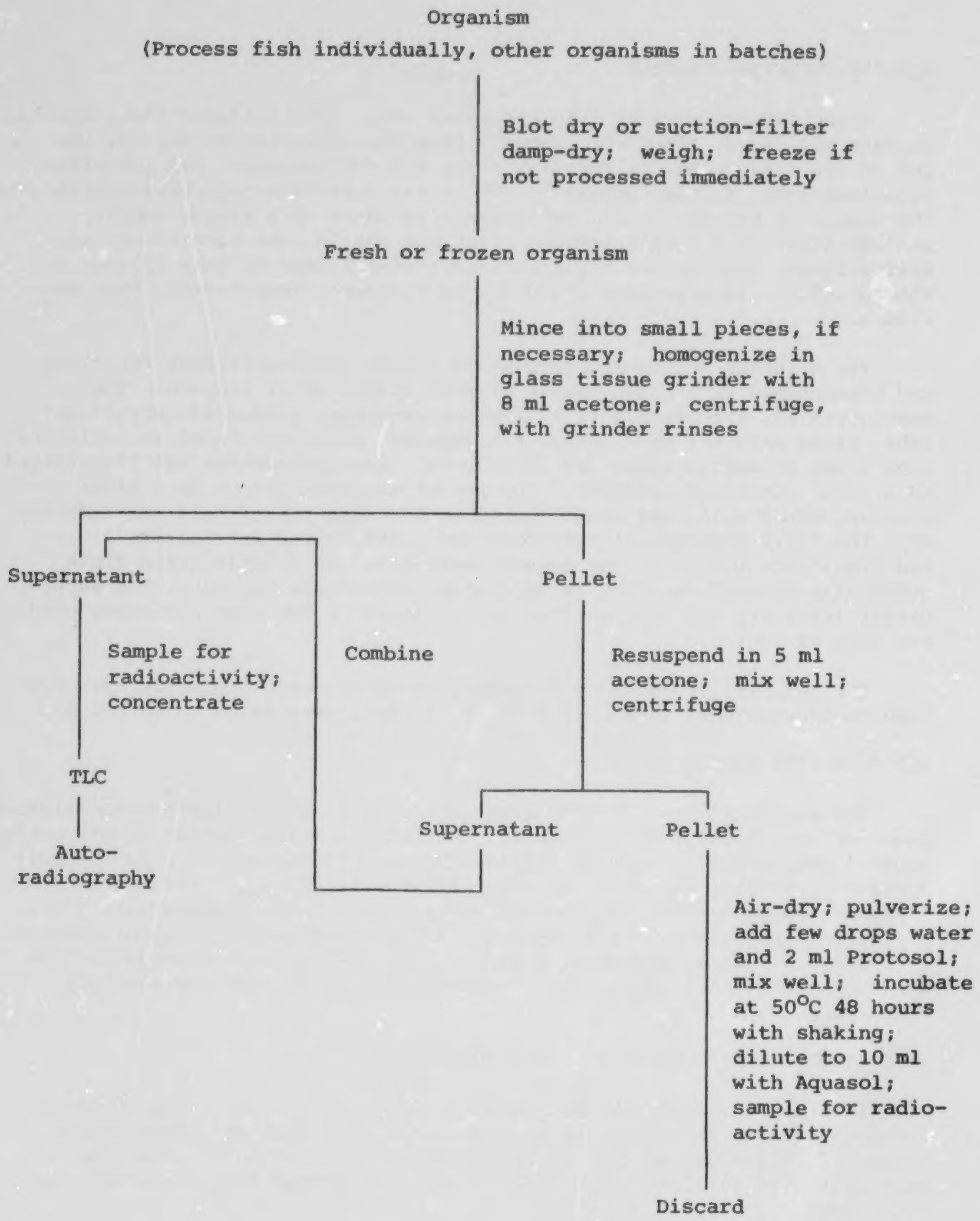

Organism
(Process fish individually, other organisms in batches)
Blot dry or suction-filter damp-dry; weigh; freeze if not processed immediately
Fresh or frozen organism
Mince into small pieces, if necessary; homogenize in glass tissue grinder with 8 ml acetone; centrifuge, with grinder rinses
Supernatant
Sample for radioactivity; concentrate
TLC
Auto-radiography
Combine
Pellet
Resuspend in 5 ml acetone; mix well; centrifuge
Supernatant
Pellet
Air-dry; pulverize; add few drops water and 2 ml Protosol; mix well; incubate at 50°C 48 hours with shaking; dilute to 10 ml with Aquasol; sample for radioactivity
Discard

Fig. 104. Aquatic organism analysis procedure (fish/snails/daphnia/algae)

In most cases, a sufficient quantity of concentrated extract was applied to assure the presence of at least 10,000 dpm in the spot. If the extract contained less than this quantity of radioactivity, the total or some fraction of the extract was applied so as to maximize the quantity of radioactivity present in the spot without overloading the spot with extract material. Extract samples were co-chromatographed with authentic unlabeled parent compound and any available metabolites of the parent compound. These unlabeled compounds were also spotted in a separate lane on each plate. A delimiting solvent front line was marked 15 cm above the orign on each plate.

The following solvent systems were employed for development of the chromatograms:

DDT: n-hexane:diethyl ether (24:1 by volume)

Methoxychlor: petroleum ether:diethyl ether (17:3 by volume)

Fonofos: carbon tetrachloride:ethyl acetate (1:1 by volume),

preferably n-hexane:chloroform (4:1 by volume), used for corn

Aldrin, dieldrin: n-hexane:diethyl ether (3:2 by volume)

Pentachlorophenol: benzene:n-hexane:acetic acid (18:1:1 by volume)

Parathion, methyl parathion, pentachloronitrobenzene, captan:

diethyl ether:n-hexane (7:3 by volume)

Phorate, simazine: benzene:acetone (4:1 by volume)

Trifluralin, 2,4,5-T isooctyl ester: n-hexane:acetone (10:1 by volume)

Following total evaporation of the solvent from the plates, the plates were set with 8x10-inch sheets of x-ray film (Kodak Blue Brand film, BB-5, Eastman Kodak Co., Rochester, N.Y.) for a period of 2 weeks if the initial spot contained at least 10,000 dpm, or increasing lengths of time if the spots contained lower levels of radioactivity. Following the exposure period, the films were developed (Kokak Liquid X-ray Developer and Replenisher), fixed (Kodak Rapid Fixer with Hardener), washed with tap water, and air-dried. The resulting autoradiograms were traced, and the tracing outlines stippled onto the chromatograms by means of a dissecting needle. The chromatograms were examined under short-wave ultraviolet light for the location of authentic compound spots (UV-absorbing against the fluorescent background). Coincidence of the authentic compound spots with the outlined spots was considered sufficient for tentative identification of the radiolabeled (outlined) spots. The outlined spots were scraped into scintillation vials containing dioxane-based scintillation fluid in order to determine radioactive content.

COST ANALYSIS OF MATERIALS AND METHODS

The terrestrial model ecosystems developed under this Contract were designed for operation in any reasonably well equipped biological laboratory. Therefore, the design has been kept as simple as possible with especial emphasis on the development of compact units that can be handled economically in standard controlled environmental chamber equipment with high intensity fluorescent lighting for plant growth. The most economical sized chambers for routine work using the terrestrial model ecosystem would appear to be the approximately 200 cubic foot models such as Sherer Gillette CEL 37-14 or Percival PT-80. These are equipped to maintain temperatures within ± 2°F, under programmed conditions and are provided with light intensities of 5000 foot candles. Units of this size can handle 6 of the terrestrial model ecosystems simultaneously. Their cost is about $5000 each. Larger walk-in environmental plant growth chambers costing $8000-$10,000 can provide space for 10-12 terrestrial model ecosystems with somewhat more convenience in working space. Such units are routinely used in almost every biological laboratory and have a life-time of many years. Therefore, we have not included their price in this Cost Analysis.

Similarly, the provision of laboratory facilities for rearing the test animals and for working up the information from each individual terrestrial model ecosystm, using extraction, thin-layer chromatography, radioautography and liquid scintillation counting involves standard laboratory equipment. Therefore, we have not included these facilities in our Cost Analysis.

RADIOLABELED PESTICIDES

These were provided by the Environmental Protection Agency specifically for the studies made under the "Substitute Chemicals Program." The individual cost is not known to us but can be estimated from comparable prices by commercial suppliers. The average cost of the following ^{14}C labeled pesticides selected from the manufacturers catalogues [1]: aldrin, dieldrin, DDT, lindane, 2,4-D, hexachlorobenzene, paraquat, and nicotine was $472 for 250 microcuries. This quantity of radioactivity is sufficient to treat 4 to 8 model ecosystems. Therefore, the average cost of the radiolabeled pesticide is estimated at $100 per individual ecosystem. Custom syntheses of new materials is somewhat more expensive but these are almost always available through the manufacturer who uses them routinely in satisfying pesticide registration requirements.

[1] Amersham Corp. 1978-79, New England Nuclear Corp. 1978

MODEL ECOSYSTEM UNITS

The costs involved with the basic terrestrial model ecosystem units are outlined in Table 166. These, averaged for the 22 terrestrial model ecosystems as developed, were $8.03 per individual model ecosystem.

ECOSYSTEM BIOTA

The costs involved in operating the terrestrial model ecosystems including the plants and animals are very modest and are indicated in Table 166. These averaged $1.34 per individual ecosystem.

CHEMICALS AND SUPPLIES

The costs of the chemicals and supplies utilized for the basic ecosystem units are itemized in Table 167. These averaged $135.41 per individual model ecosystem.

REARING SUPPLIES

The costs of the dietary materials and supplies and in rearing the various animals utilized in the model ecosystem units, i.e. isopod, slug, salt marsh caterpillar, vole, mosquito larva, fish, etc. are itemized in Table 168. These averaged $12.18 per individual model ecosystem.

MISCELLANEOUS CONSUMABLE SUPPLIES

The costs of miscellaneous items involved in evaluating the results of the model ecosystem studies, e.g. TLC plates, X-ray film for radioautography, chemicals for trapping volatiles, etc. are itemized in Table 169. These averaged $22.70 per individual model ecosystem.

TOTAL COST OF INDIVIDUAL MODEL ECOSYSTEM EVALUATION

Based on the itemization in Tables 166-169 and calculated as the average cost of the 22 model ecosystems run under this Contract the following cost is obtained for each individual model ecosystem determination.

radiolabeled compound	$100.00
model ecosystem unit	8.03
biota	1.34
chemicals	135.41
rearing supplies	12.18
miscellaneous consumable supplies	25.70
Total	$282.66

This figure does not include labor or depreciation of standard laboratory equipment.

Table 166. Costs of Terrestrial Model Ecosystem Units

	Quantity per eco-system	Purchase unit	Unit price	Expected cost per initial ecosystem	Actual cost per initial ecosystem	Expected cost per 22 eco-systems	Actual cost per 22 eco-systems
A. Ecosystem unit							
1. Glass carboy, 19-liter, wide-mouth, with metal screw-on lid	1	ea	9.00	9.00	9.00	144.00	144.00
2. Stainless steel tubing, 7.5 mm ID x 3/8" OD	30"	ft	1.50	4.50	4.50	4.50	4.50
3. Silver solder	2g	oz	12.00	12.00	12.00	12.00	12.00
4. Neoprene "O" ring gasket, 13 cm OD	1	ea	.40	.40	.40	4.80	4.80
5. Polyethylene twistcock tap	1	ea	.75	.75	.75	3.75	3.75
6. Copper mesh screening, 1" x 2"	1	sq. ft.	3.00	3.00	3.00	3.00	3.00
7. Vinyl tubing, 1/2" ID x 1/8" wall	2 cm	5 ft	.96	.96	.96	.96	.96
8. Silicone cement	1/10 tube	tube	2.00	2.00	2.00	2.00	2.00
9. Nylon mesh fabric, coarse, 8" x 8"	1	yd	.59	.59	.59	1.18	1.18
10. Rubber band, 1/8" x 2-1/2"	6	1/4 lb box	.40	.40	.40	.40	.40
B. Ecosystem unit contents (excluding animals)							
1. Vermiculite	400 g	24 lb bag	9.49	9.49	9.49	9.49	9.49
or	or						
Drummer silty clay loam soil	3000 g	Collected free					
or	or						
Bloomfield loamy sand	3000 g	Collected free					
2. Corn seeds	50	Free from seed company					
or	or						
Soybean seeds	50	Free from seed company					
3. Distilled water	2.1	No charge					
4. Plastic cup, 2-oz	3	500/pkg	5.00	5.00	5.00	5.00	5.00
5. Tap water	60 ml	No charge					
C. Animals							
1. Pillbug	20	Collected free					
2. Saltmarsh caterpillar	10	Maintained in colony					
3. Garden slug	10	Collected free					
4. Earthworm	10	doz	.75	.75	.75	15.00	15.00
5. Prairie vole	1	Maintained in colony					
6. Snail	50	Maintained in indoor pond					
7. Daphnia	300	Maintained in indoor pond					
8. Mosquito larvae	300	Maintained in insectory					
9. Mosquito fish	3	Maintained in aquarium					

Table 167. Costs of Laboratory Chemicals for Terrestrial Model Ecosystems

	Quantity per eco-system	Purchase unit	Unit price	Expected cost per initial ecosystem	Actual cost per initial ecosytem	Expected cost per 22 eco-systems	Actual cost per 22 eco-systems
Chemicals							
1. $MgSO_4 \cdot 7H_2O$	639 mg	lb	2.03	2.03		2.03	
2. K_2SO_4	58.5 mg	lb	1.93	1.93		1.93	
3. $MnSO_4 \cdot 4H_2O$	1.8 mg	lb	2.03	2.03		2.03	
4. $CaCl_2 \cdot 2H_2O$	167.4 mg	lb	1.98	1.98		1.98	
5. $NaHCO_3$	225 mg	lb	.97	.97		.97	
6. NH_4NO_3	27 mg	lb	1.66	1.66		1.66	
7. $K_2HPO_4 \cdot 3H_2O$	9.9 mg	lb	1.68	1.68		1.68	
8. CaO	289.8 mg	lb	1.35	1.35		1.35	
9. $Na_2SiO_3 \cdot 9H_2O$	563.4 mg	lb	5.00	5.00		5.00	
10. $FeCl_3 \cdot 6H_2O$	10.8 mg	lb	2.24	2.24		2.24	
11. Distilled water	8 l	No charge					
12. Acetone, bulk technical	3 gal	5 gal	11.75	11.75	11.75	164.50	164.50
13. Acetone, reagent grade	2 l.	gal	4.04	4.04	4.04	48.48	48.48
14. Methanol	1 l.	gal	4.46	4.46	4.46	31.22	31.22
15. Ether (diethyl)	4 l.	12 x 1 lb	22.05	22.05	22.05	264.50	264.50
16. Hexane	1 l.	qt	3.28				
or	or						
Benzene	1 l.	pt	.88				
or	or						
Chloroform	1 l.	pt	1.53	avg.3.25	3.25	71.50	71.50
or	or						
Petroleum ether	1 l.	gal	4.10				
or	or						
Ethyl acetate	1 l.	pt	2.02				
17. Ethanol	50 ml	pt	.94	.94	.94	1.88	1.88
18. Sodium bisulfite	10 g	lb	2.27	2.27	2.27	2.27	2.27
19. Iodine crystals	100 g	lb	9.97	9.97	9.97	9.97	9.97
20. Conc. HCl	2 ml	6 lb btl	2.86	2.86	2.86	2.86	2.86
21. Glacial acetic acid	100 ml	5 lb btl	8.16	8.16	8.16	8.16	8.16
22. Protosol	100 ml	500 ml btl	57.00	57.00	57.00	171.00	171.00
23. (^{14}C) Toluene standard	5 ml	10 ml	25.00	25.00		25.00	
24. Dioxane	10 l.	gal	14.49	43.47	43.47	883.89	883.89
25. PPO	70 g	100 g	16.80	16.80	16.80	268.80	268.80
26. POPOP	.5 g	5 g	5.60	5.60	5.60	16.80	16.80
27. Naphthalene	1.2 kg	2.5 lb	8.46	8.46	8.46	186.12	186.12
28. Aquasol	3 l.	4-l. btl	45.00	45.00	45.00	765.00	765.00
29. Drierite desiccant (indicating)	1 lb	lb	2.71	2.71	2.71	8.12	8.13
30. Dekasol radioactive decontaminant	50 ml	qt	6.00	6.00	6.00	6.00	6.00
31. Sodium dichromate	2.5 lb	5 lb	5.02	5.02	5.02	10.04	10.04
32. Conc. sulfuric acid, technical	15 btls	10 lb btl	.43	6.02	6.02	12.04	12.04

Table 168. Costs of Rearing Supplies for Terrestrial Model Ecosystem

	Quantity per eco-system	Purchase unit	Unit price	Expected cost per initial ecosystem	Actual cost per initial ecosystem	Expected cost per 22 eco-systems	Actual cost per 22 eco-systems
A. Feed diet components							
1. Honey	.4 g	lb	1.09	1.09		1.09	
2. Tap water	760 ml	No charge					
3. Agar	12.5 g	lb	11.00	11.00		22.00	
4. Casein, vitamin-free	32 g	5 lb	10.95	10.95		10.95	
5. Alfalfa meal	14 g	10 lb	5.00	5.00		5.00	
6. Sucrose	24 g	1 lb	1.89	1.89		5.67	
7. Wheat germ	27 g	5 lb	4.00	4.00		4.00	
8. Wesson's salts	9 g	5 lb	7.30	7.30		7.30	
9. Alphacel	4.5 g	5 lb	4.29	4.29		4.29	
10. KOH	1 g	1 lb	1.21	1.21		1.21	
11. Vanderzant vitamin mixture	9 g	1 kg	24.08	24.08		24.08	
12. Sorbic acid	1.7 g	200 g	2.50	2.50		2.50	
13. Methyl p-hydroxy benzoate	1.7 g	100 g	3.21	3.21		3.21	
14. Ascorbic acid	3.3 g	50 g	1.75	1.75		5.25	
15. Aureomycin	.25 g	5 g	11.25	11.25		22.50	
16. Cholesterol	.6 g	25 g	2.44	2.44		2.44	
17. Choline chloride	1 g	200 g	2.11	2.11		2.11	
18. Wheat germ oil	1.8 ml	lb	4.35	4.35		4.35	
19. Linolenic acid, technical	.5 ml	250 g	5.20	5.20		5.20	
20. Inesitol	.6 g	100 g	3.00	3.00		3.00	
21. Formaldehyde (37%)	1 ml	pt	.92	.92		.92	
22. Sweet alyssum	2 plants	Maintained in greenhouse					
23. Dog chow	1 lb	5 lb	1.46	1.46	1.46	1.46	1.46
24. Rabbit chow	5 lb	50 lb	6.78	6.78	6.78	13.56	13.56
25. Mouse chow	5 lb	50 lb	11.97	11.97	11.97	23.94	23.94
26. Tropical fish food	.25 oz	2 oz	2.89	2.89	2.89	14.45	14.45
B. Rearing supplies							
1. Moist newspaper	3 shts	No charge					
2. Cedar chips	1 cup	25 lb	3.64	3.64	3.64	3.64	3.64
3. Gravel	2 cups	Collected free					
4. Plastic pill cup, 1-oz	35	5000/pkg	35.50	35.50		35.50	
5. Cardboard lid for pill cup	35	1000/pkg	2.00	2.00		2.00	
6. Pill cup tray	1	ea	.50	1.00		5.00	
7. Cotton dental wick	2	1000/box	6.56	6.56		6.56	
8. Cellucotton circle, 8-inch diam	1	300 ft rl	12.94	Included under III, H. 8			
9. Brown wrapping paper, 15" x 600 ft	2 ft	600 ft rl	6.35	6.35		6.35	
10. Fine nylon mesh, 10" x 10"	1	yd	3.00	3.00		3.00	
11. Cardboard ice cream carton w/lid, gal.	1	50/cs	15.54	15.54		15.54	
12. Sand	5 lb	100 lb	2.24	Inlcuded under I. D. 11			
13. Distilled water	3 cups	No chge					
14. Aluminum foil, 12" x 10 lb	3 ft	10 lb	12.82	Included under I. D. 13			

Table 169. Miscellaneous Consumable Supplies Specifically Required

		Quantity per eco-system	Purchase unit	Unit price	Expected cost per initial ecosystem	Actual cost per initial ecosystem	Expected cost per 22 eco-systems	Actual cost per 22 eco-systems
1.	Acetonitrile	600 ml	1 gal	12.04	12.04	12.04	48.16	48.16
2.	Ethanolamine	150 ml	1 gal	14.60	14.60	14.60	14.60	14.60
3.	4-Methoxyphenol	300 ml	7 lb btl	8.35	8.35	8.35	16.70	16.70
4.	Silica gel impregnated TLC plates, 20 cm^2	8	25/pkg	24.25	24.25	24.25	145.50	145.50
5.	Silica gel GF-254	100 g	500 g	15.82	15.82	15.82	47.46	47.46
6.	Combustion cones for Packard oxidizer	10	1000/pkg	65.20	65.20	65.20	65.20	65.20
7.	X-ray film 8"x10"	12	50/pkg	25.00	25.00	25.00	150.00	150.00
8.	X-ray developer	1 qt	1 gal	2.47	2.47	2.47	14.82	14.82
9.	X-ray fixer	1 qt	1 gal	2.08	2.08	2.08	12.48	12.48
10.	Sand	5 lb	100 lb	2.24	2.24	2.24	2.24	2.24
11.	Aluminum foil, 12" wide	2 ft	10 lb rl	12.82	12.82	12.82	12.82	12.82
12.	Vinyl tubing 1/8" ID x 1/16" wall	3 ft	10 ft	0.63	0.63	0.63	1.25	1.26
13.	Silicone tubing 3/16" ID x 3/32" wall	8 in	1 ft	0.46	0.46	0.46	1.38	1.38
14.	Teflon joint sleeve	2	6/pkg	14.50	14.50	14.50	29.00	29.00
15.	Wooden applicators	5 doz	72 doz/bx	1.91	1.91	1.91	3.82	3.82

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